THE HEART (1)

(PERICARDIUM, SURFACES, BORDERS AND CHAMPERS)

Lecture (6)
Last updated: April 2013

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Objectives:

- **Basic anatomy, to identify:**
  - Parts and layers of pericardium.
  - Valves of the heart.
  - Chambers of the hearts.
  - Features of each chambers.
- **Surface anatomy, to identify:**
  - Borders, valves of the heart.
  - Where to listen for heart sounds.

- **Clinical anatomy, to define:**
  - Pericardial effusion.
  - Pericarditis.
  - Pericardiocentesis
- **Radiology:**
  - Normal chest X-Ray.
  - Normal Chest CT

Think about this

- A resident doctor in the emergency medicine department has been called to examine an old patient in the ward of the cardiology, the patient was severely ill, with marked weight loss, on examination pulse rate was 100 bpm, respiratory rate 22 per minute, neck veins were engorged, heart sounds were diminished and the liver was enlarged (hepatomegaly).
- The nurse mentioned to the doctor that the patient has been admitted a few days ago and diagnosed as having Myocardial infarction; she also mentioned that he is under chemotherapy.

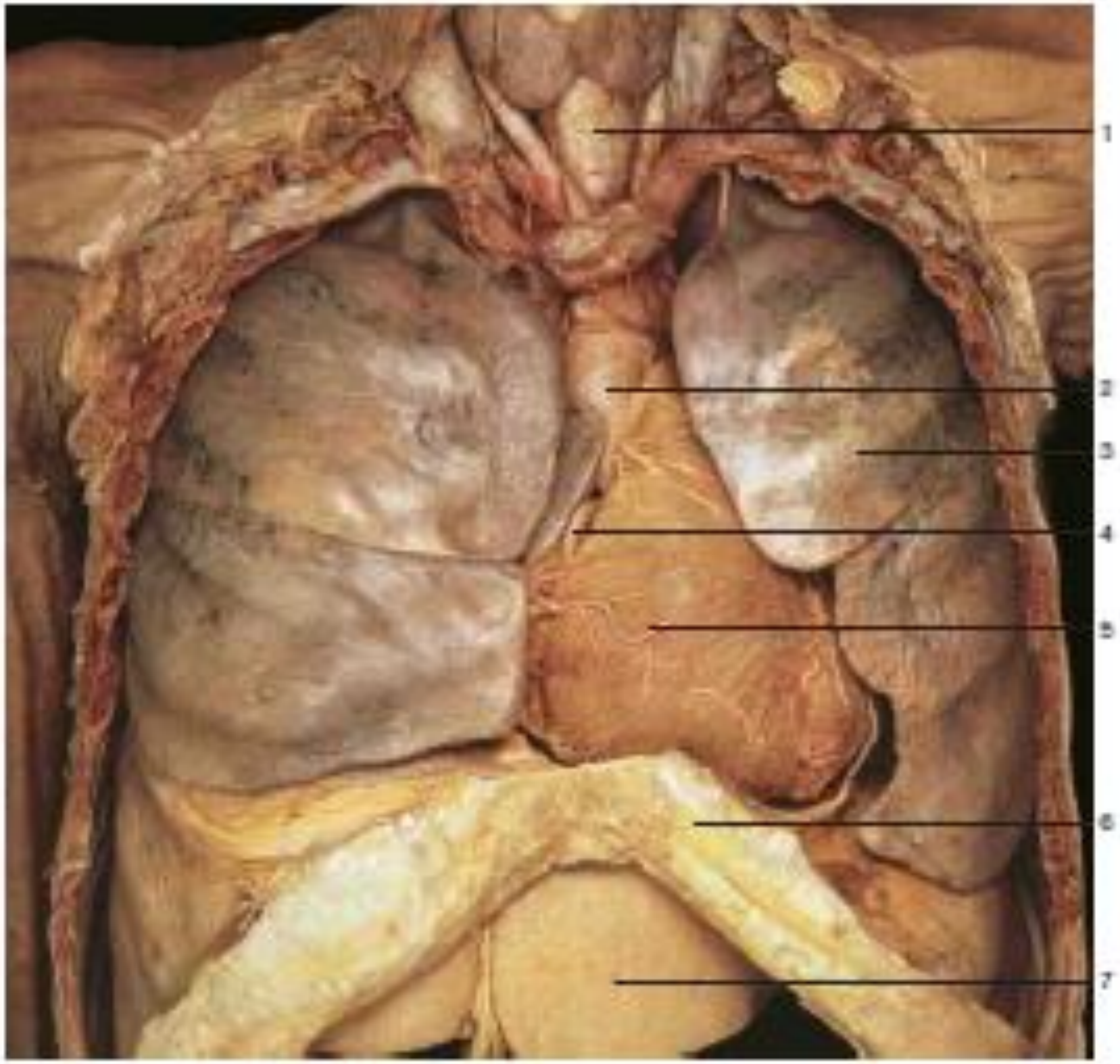
By the end of this lecture, try to answer these questions about the previous story:

- What is the possible diagnosis?
- What are the causes of the:
    - Engorged neck veins?
    - Diminished heart sounds?
    - Hepatomegaly?
- Mention the surface marking for the heart.

Introduction: Lecture's map

- Pericardium.
- Heart:
  - Surfaces and borders.
  - Valves.
  - Champers.

Heart



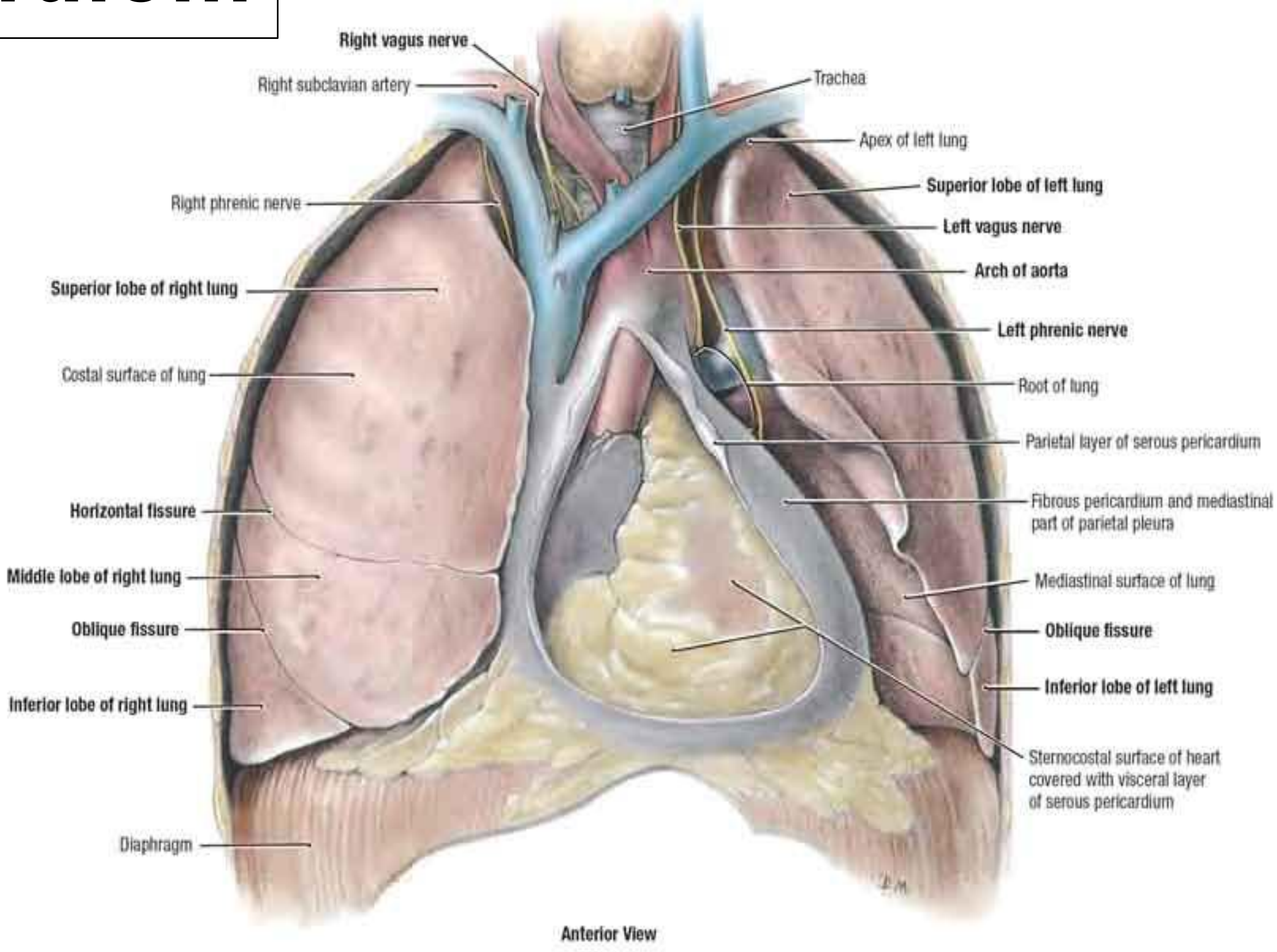
1 Trachea
2 Ascending aorta
3 Left lung
4 Right coronary artery
5 Heart (right ventricle)
6 Costal arch
7 Liver

Thoracic organs, heart, and lungs in situ (ventral aspect). Anterior thoracic wall, parietal pleura, and pericardium have been removed.

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

Pericardium

Pericardium

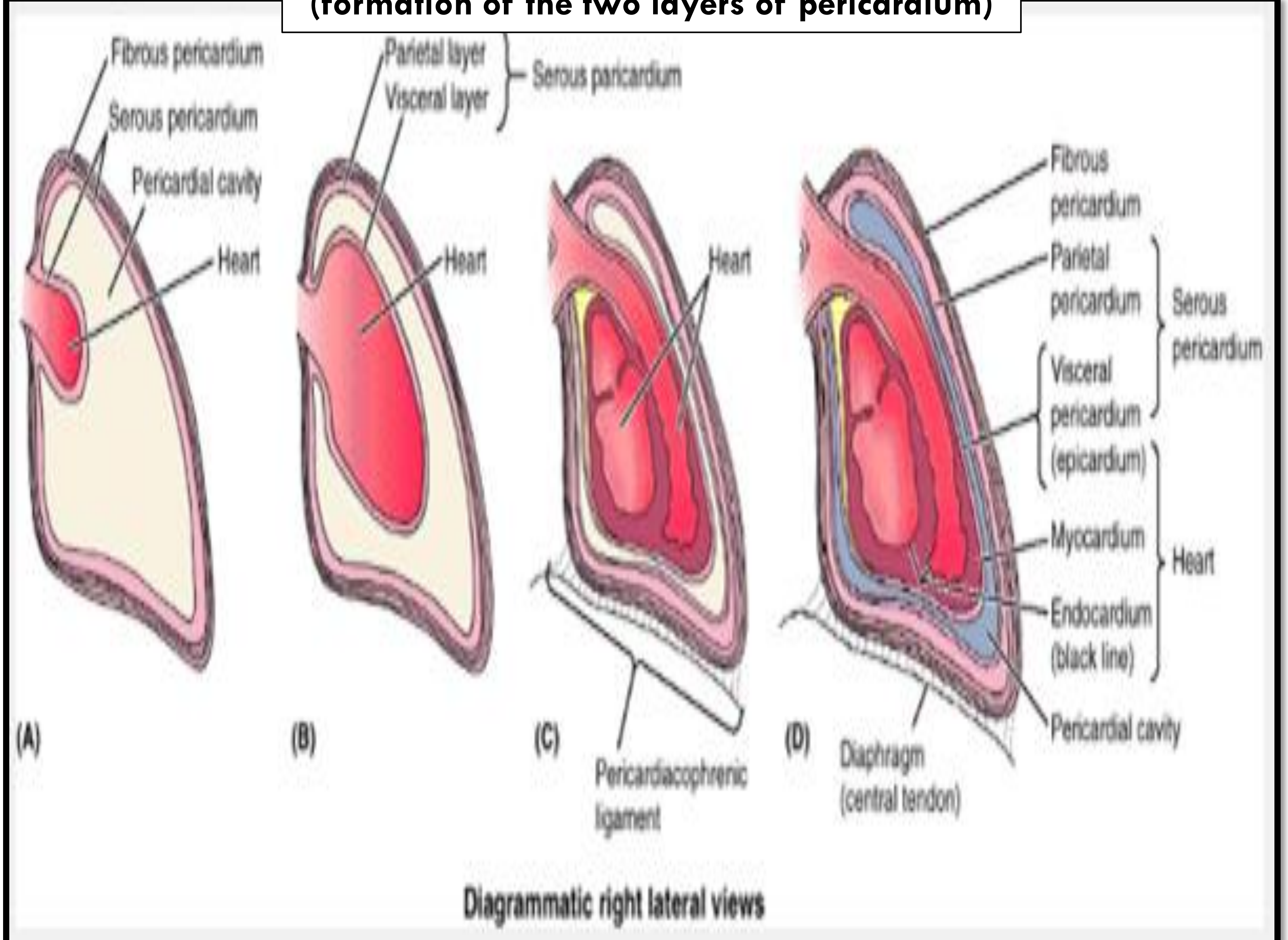

Right vagus nerve
Right subclavian artery
Trachea
Apex of left lung
Right phrenic nerve
Superior lobe of left lung
Left vagus nerve
Arch of aorta
Superior lobe of right lung
Left phrenic nerve
Costal surface of lung
Root of lung
Parietal layer of serous pericardium
Fibrous pericardium and mediastinal part of parietal pleura
Horizontal fissure
Middle lobe of right lung
Mediastinal surface of lung
Oblique fissure
Oblique fissure
Inferior lobe of left lung
Inferior lobe of right lung
Sternocostal surface of heart covered with visceral layer of serous pericardium
Diaphragm

Anterior View

Pericardium

- It is a closed sac composed of two layers.
  - Fibrous pericardium.
  - Serous pericardium.

Development of the heart
(formation of the two layers of pericardium)



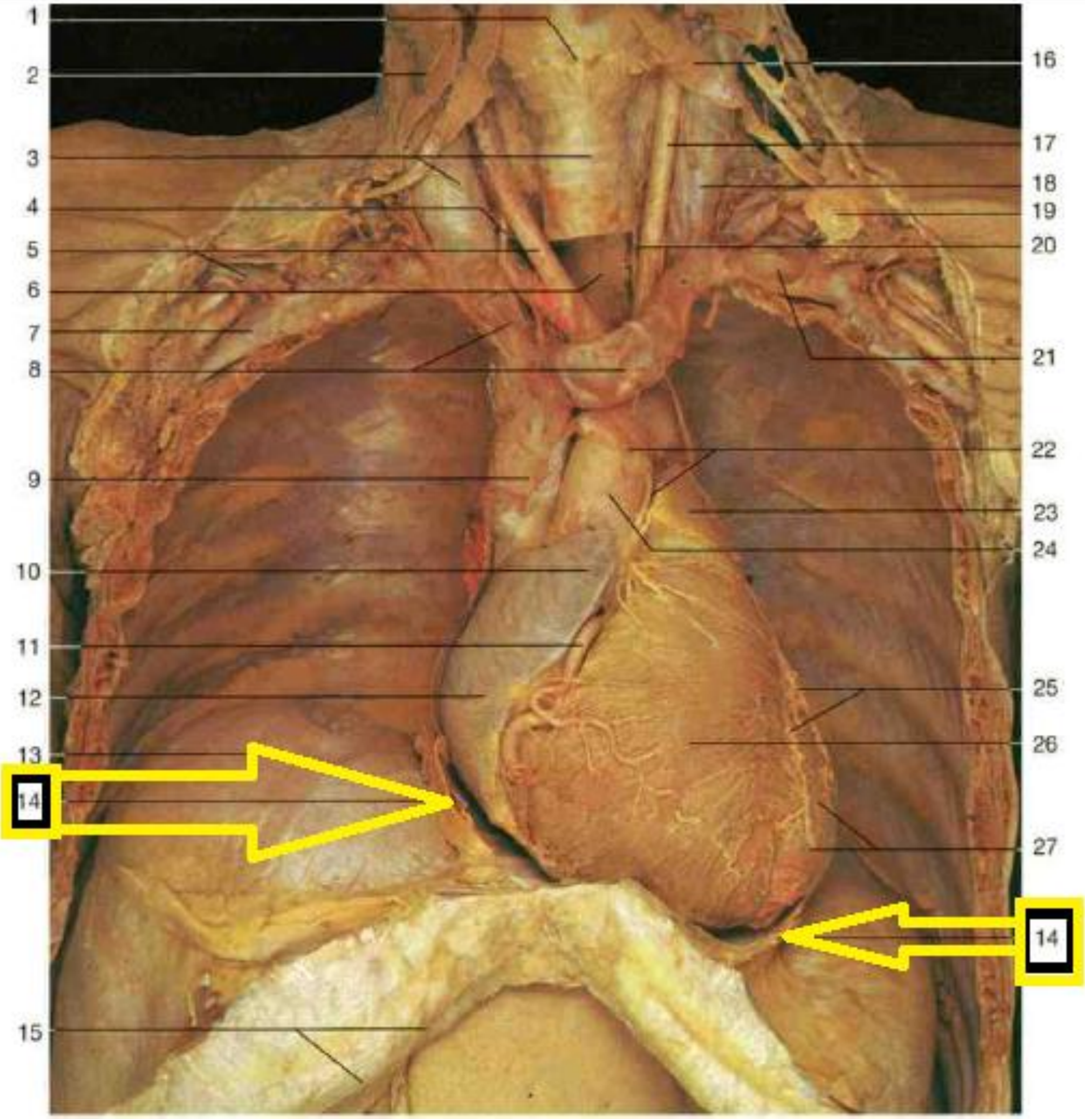
Diagrammatic right lateral views

Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

The fibrous pericardium

- **Superiorly**:
  - It continuous with the tunica adventitia of the great vessels of the heart and with the pretracheal layer of deep cervical fascia.
- **Inferiorly**:
  - It continuous with the central tendon of the diaphragm.

Pericardium



Heart and related vessels in situ (anterior aspect). Anterior thoracic wall, pericardium, and epicardium have been removed; trachea divided.

1 Larynx (thyroid cartilage)
2 Sternocleidomastoid muscle (divided)
3 Trachea (divided) and right internal jugular vein
4 Vagus nerve
5 Right common carotid artery and cephalic vein
6 Esophagus
7 Right axillary vein
8 Right and left brachiocephalic veins
9 Superior vena cava
10 Right auricle
11 Right coronary artery
12 Right atrium
13 Diaphragm
14 Pericardium (cut edges)
15 Costal margin
16 Omohyoid muscle
17 Left common carotid artery
18 Left internal jugular vein
19 Clavicle (divided)
20 Left recurrent laryngeal nerve
21 Subclavian vein
22 Pericardial reflection
23 Pulmonary trunk
24 Ascending aorta
25 Anterior interventricular sulcus and anterior interventricular branch of left coronary artery
26 Right ventricle
27 Left ventricle
28 Aortic valve
29 Tricuspid or right atrioventricular valve
30 Inferior vena cava
31 Pulmonary veins
32 Pulmonary valve
33 Left atrioventricular (bicuspid or mitral) valve

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

The fibrous pericardium

- **Posteriorly**:
  - It is bound by loose connective tissue to structures in the posterior mediastinum.
- **Anteriorly**:
  - It is attached to the posterior surface of the sternum by the sternopericardial ligaments.

Transverse sinus

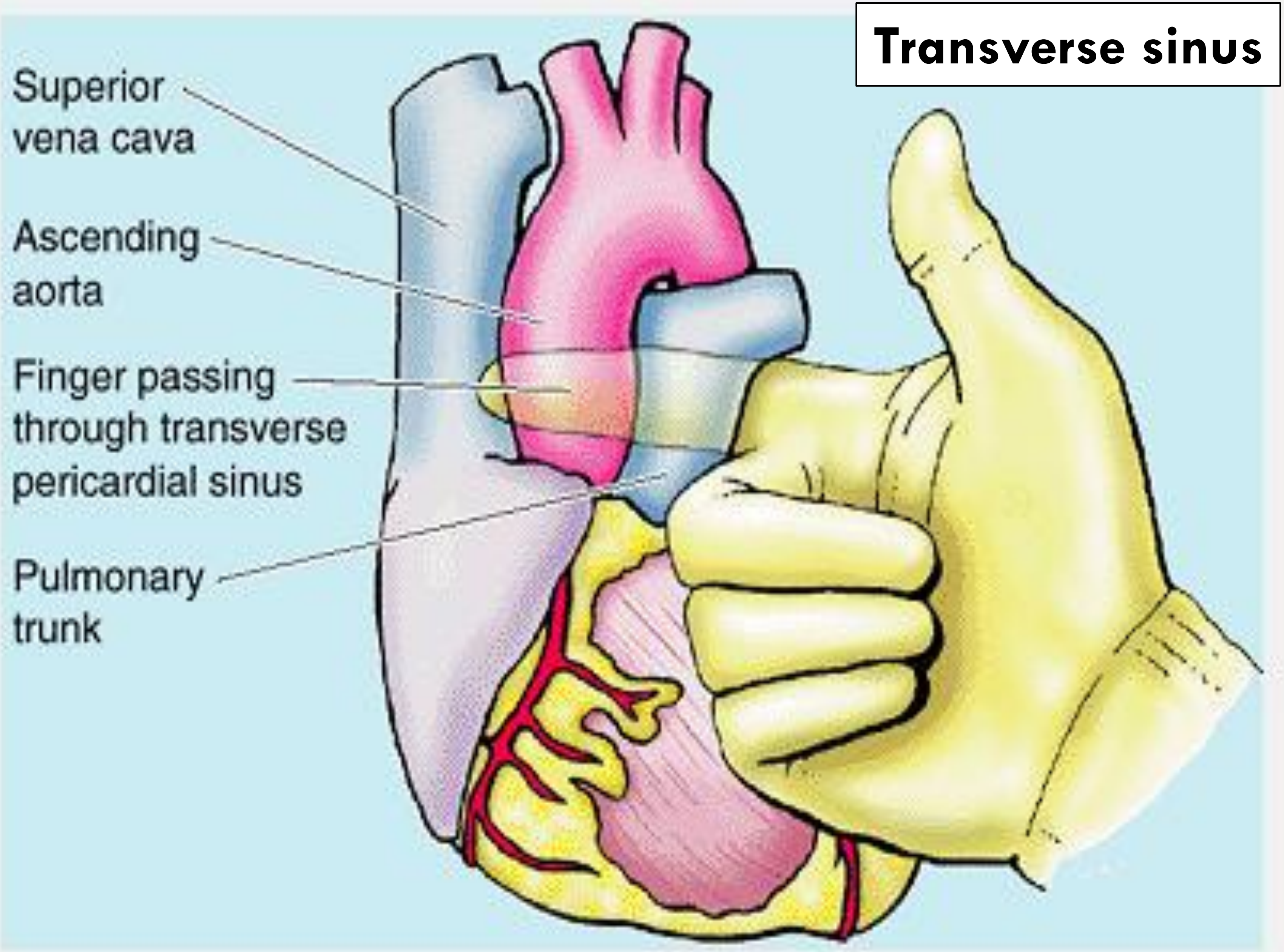


Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

The transverse pericardial sinus

- It is a space that lies:
  - Posterior to the pulmonary trunk and ascending aorta.
  - Anterior to the SVC.
  - Superior to the atria of the heart.

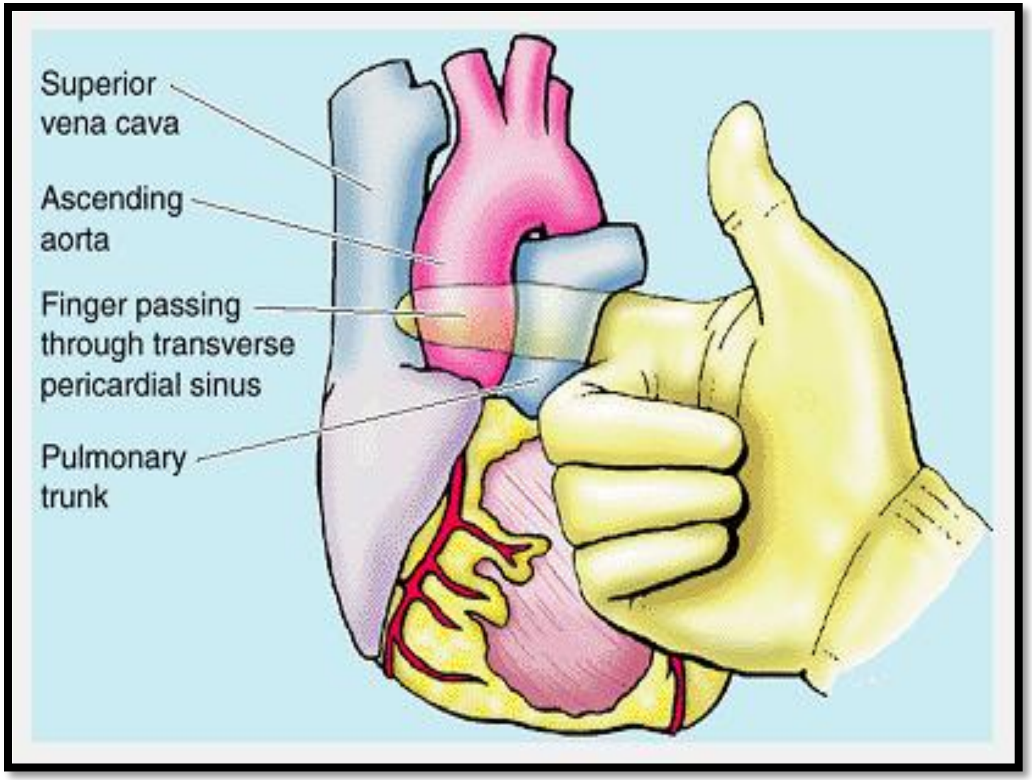
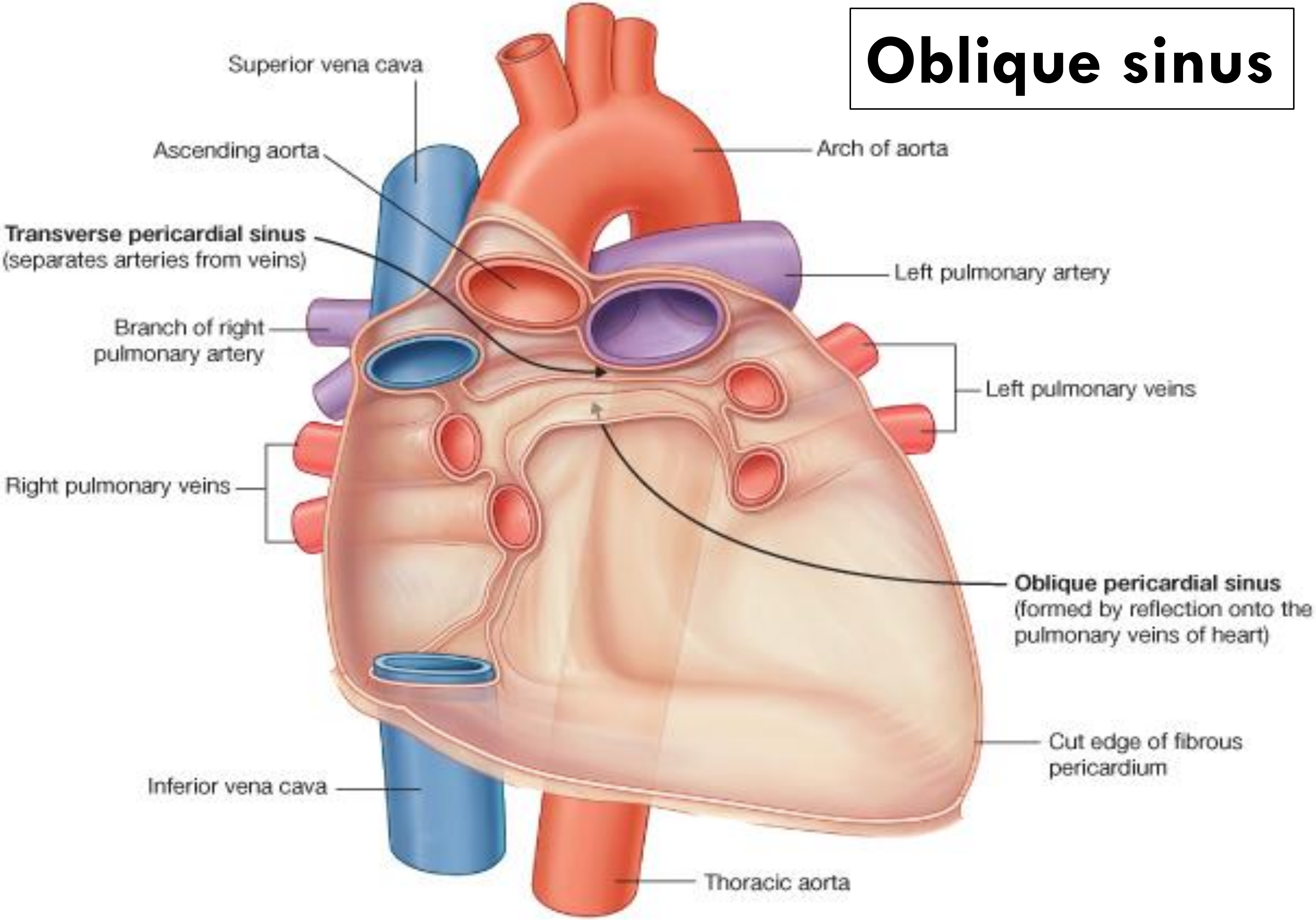


Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

Oblique sinus


Superior vena cava
Ascending aorta
Arch of aorta
Transverse pericardial sinus
(separates arteries from veins)
Left pulmonary artery
Branch of right pulmonary artery
Left pulmonary veins
Right pulmonary veins
Oblique pericardial sinus
(formed by reflection onto the pulmonary veins of heart)
Cut edge of fibrous pericardium
Inferior vena cava
Thoracic aorta

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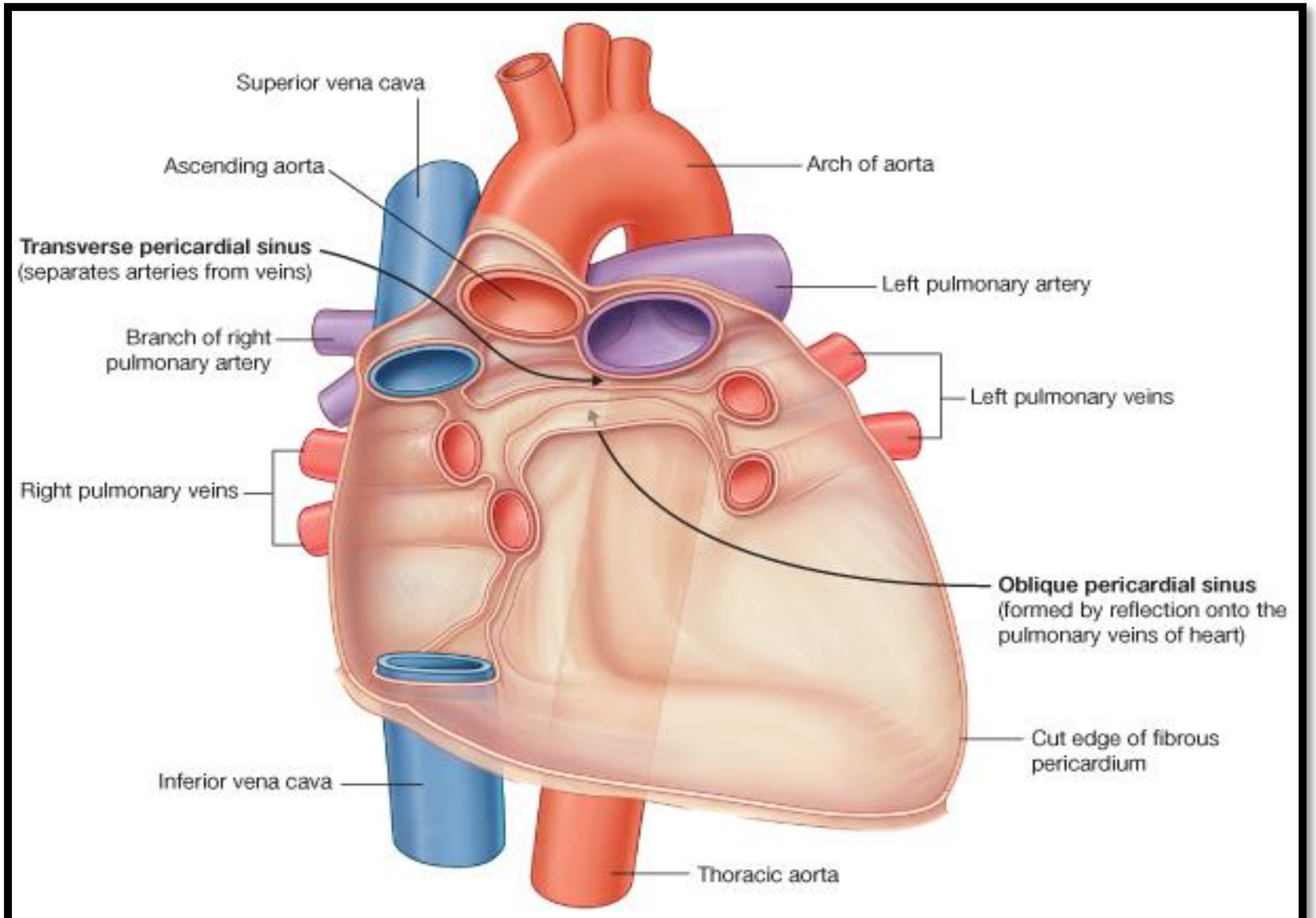
- **The oblique pericardial sinus:**
  - A wide pocket-like recess in the pericardial cavity posterior to the base (posterior aspect) of the heart.


Superior vena cava
Ascending aorta
Arch of aorta
Transverse pericardial sinus
(separates arteries from veins)
Left pulmonary artery
Branch of right pulmonary artery
Left pulmonary veins
Right pulmonary veins
Oblique pericardial sinus
(formed by reflection onto the pulmonary veins of heart)
Cut edge of fibrous pericardium
Inferior vena cava
Thoracic aorta

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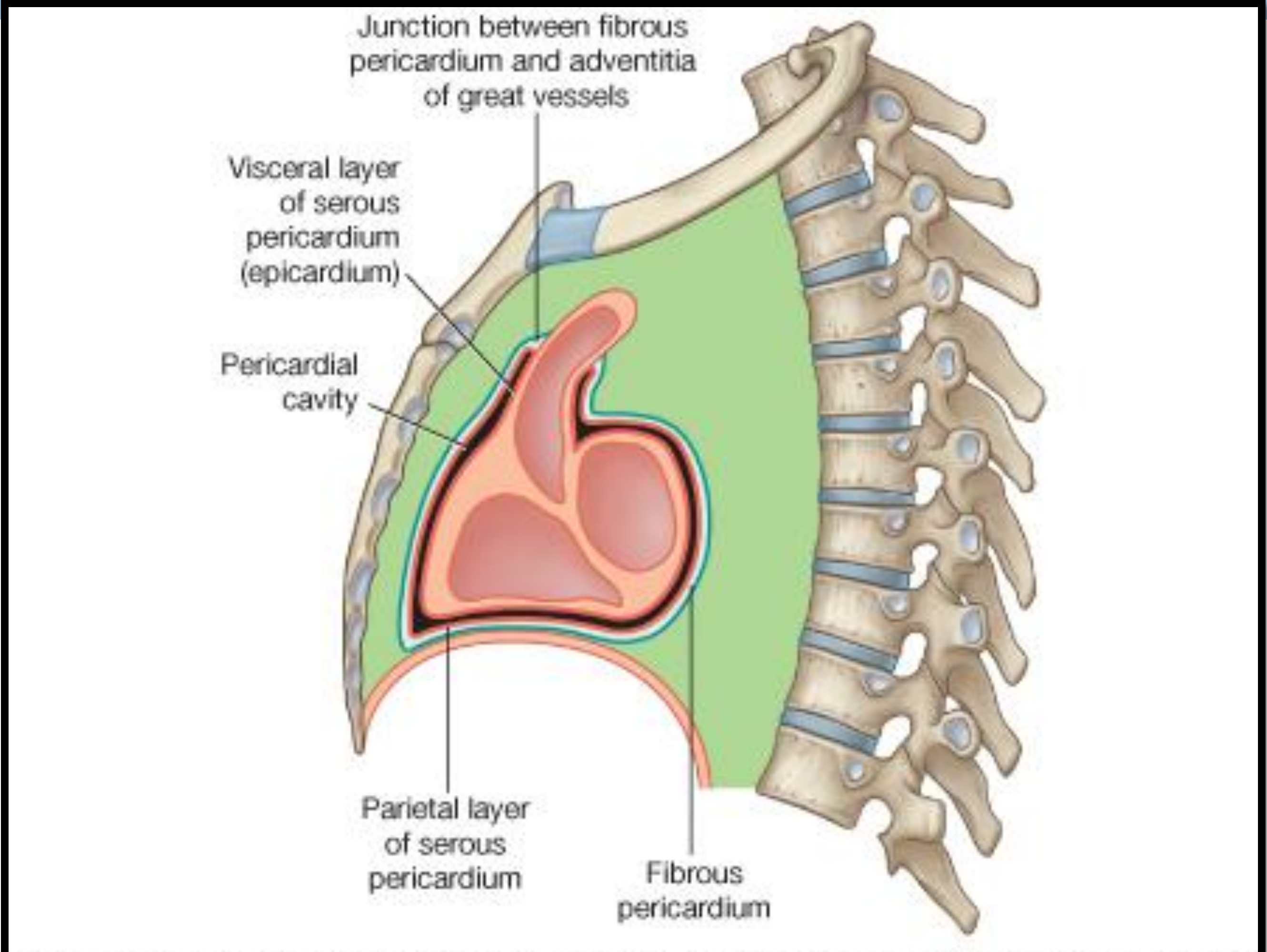
Serous Pericardium

- **Parietal** layer of serous pericardium:
  - Lines the internal surface of the fibrous pericardium.
- **Visceral** layer of serous pericardium:
  - Lines the heart.

Serous Pericardium


Junction between fibrous pericardium and adventitia of great vessels
Visceral layer of serous pericardium (epicardium)
Pericardial cavity
Parietal layer of serous pericardium
Fibrous pericardium

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Pericardial cavity

- It is the potential space between the parietal and visceral layers of serous pericardium.
- It contains a thin film of fluid that enables the heart to move and beat in a frictionless environment.

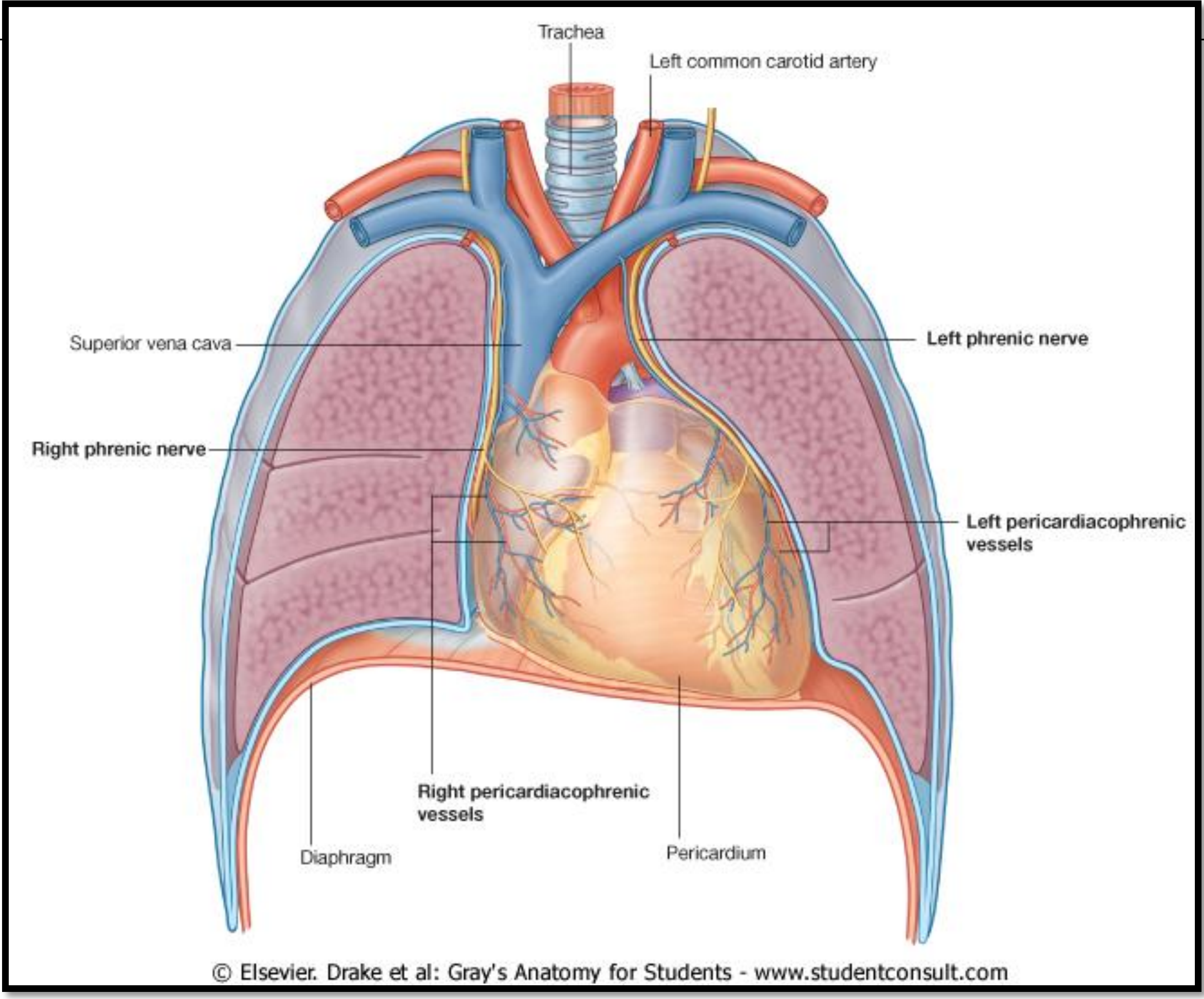
Clinical note: Pericardial effusion

- In certain situations, the pericardial cavity can be filled with excess fluid (pericardial effusion).
- Rapid accumulation of excess fluid within the pericardial sac will compress the heart (cardiac tamponade).

Arterial supply of the pericardium

- It is mainly from the pericardiacophrenic artery
- Smaller contributions of blood come from the:
  - Musculophrenic artery.
  - Bronchial, esophageal, and superior phrenic arteries.
  - Coronary arteries (visceral layer of serous pericardium only).

Arteries and veins of the pericardium


Trachea
Left common carotid artery
Superior vena cava
Left phrenic nerve
Right phrenic nerve
Left pericardiacophrenic vessels
Right pericardiacophrenic vessels
Diaphragm
Pericardium

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Venous drainage of the pericardium

- Pericardiacophrenic veins.
- Variable tributaries of the azygos venous system.

Innervation of the pericardium

- **Phrenic nerves (C3 to C5).**
- **Sympathetic trunks: vasomotor.**

Clinical note: Pericarditis

- It is an inflammatory condition of the pericardium.
- As in patients with myocardial infarction, patients with pericarditis complain of continuous central chest pain that may radiate to one or both arms.
- An electrocardiogram (ECG) is used to help differentiate between the two conditions.

Pericardiocentesis

To relieve cardiac tamponade.

1. a needle may be inserted through the left 5th or 6th intercostal space near the sternum.
2. Or by entering the infrasternal angle and passing the needle superoposteriorly .

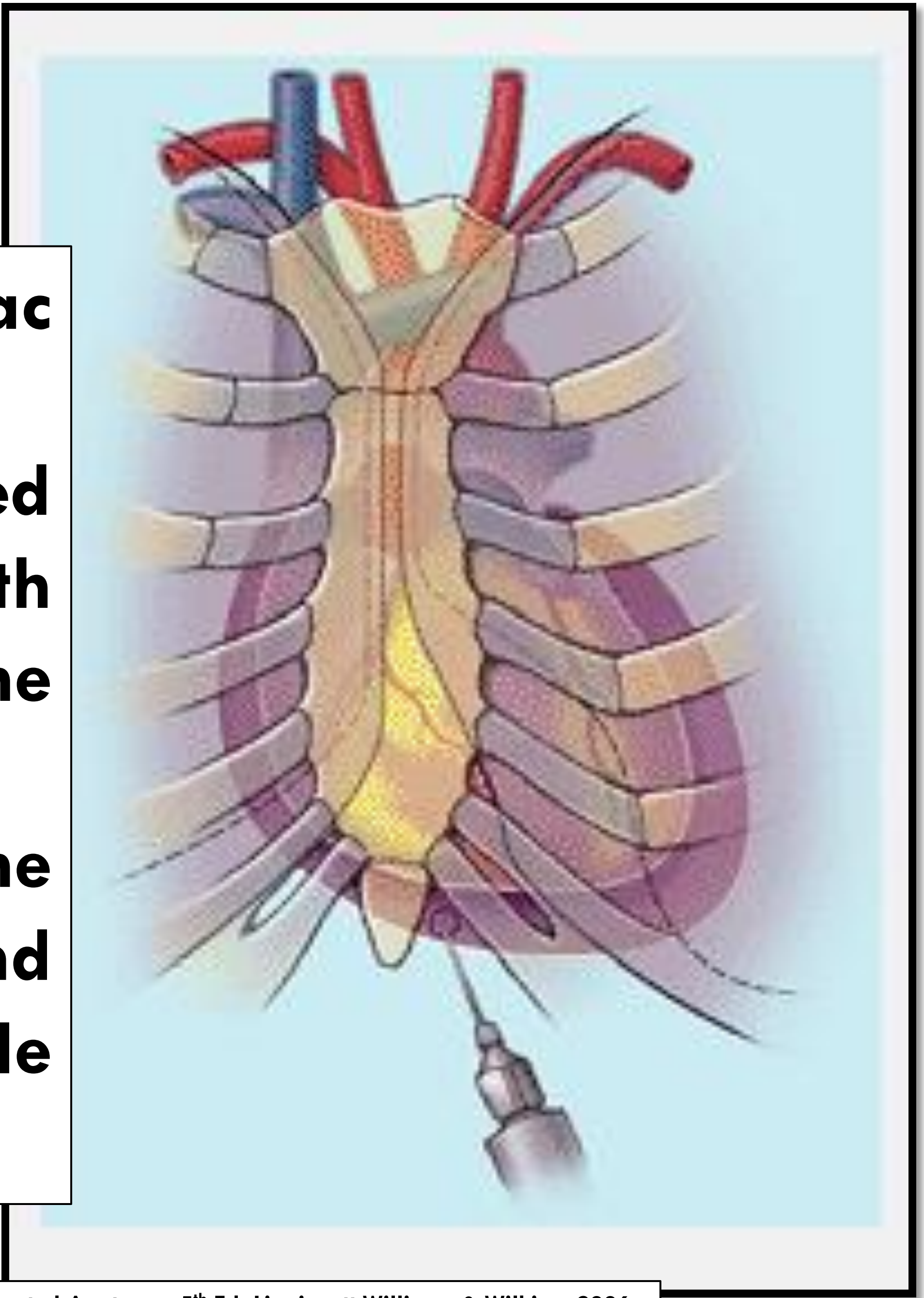
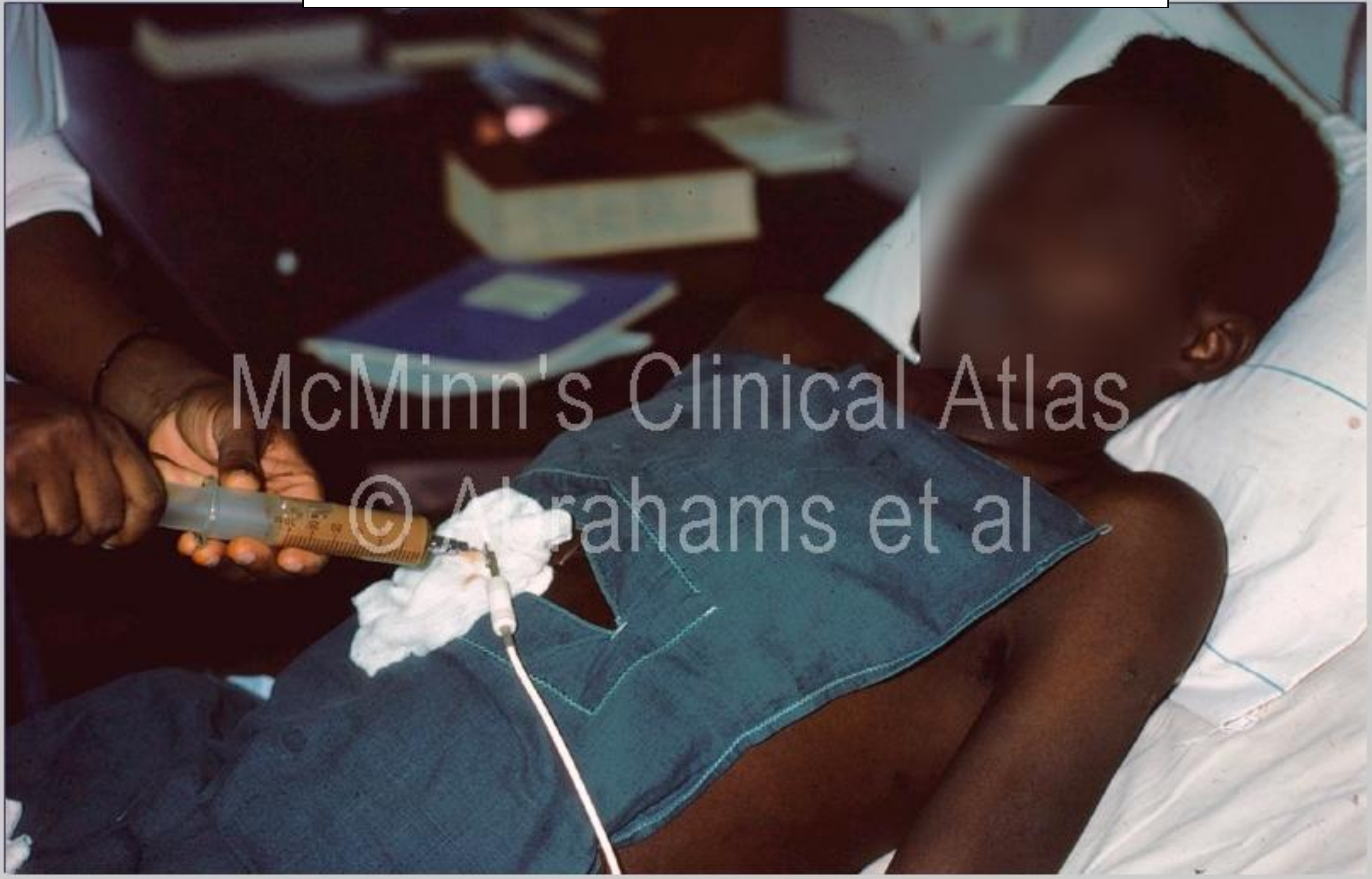


Image from: Moore, Keith L.; Dalley, Arthur F, Clinically Oriented Anatomy, 5th Ed. Lippincott Williams & Wilkins; 2006.

Clinical note: Pericardiocentesis



McMinn's Clinical Atlas
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Image from: Abraham's et al , McMinn clinical atlas.

Lecture's map

- Pericardium.
- Heart:
  - Surfaces and borders.
  - Valves.
  - Champers.

THE HEART

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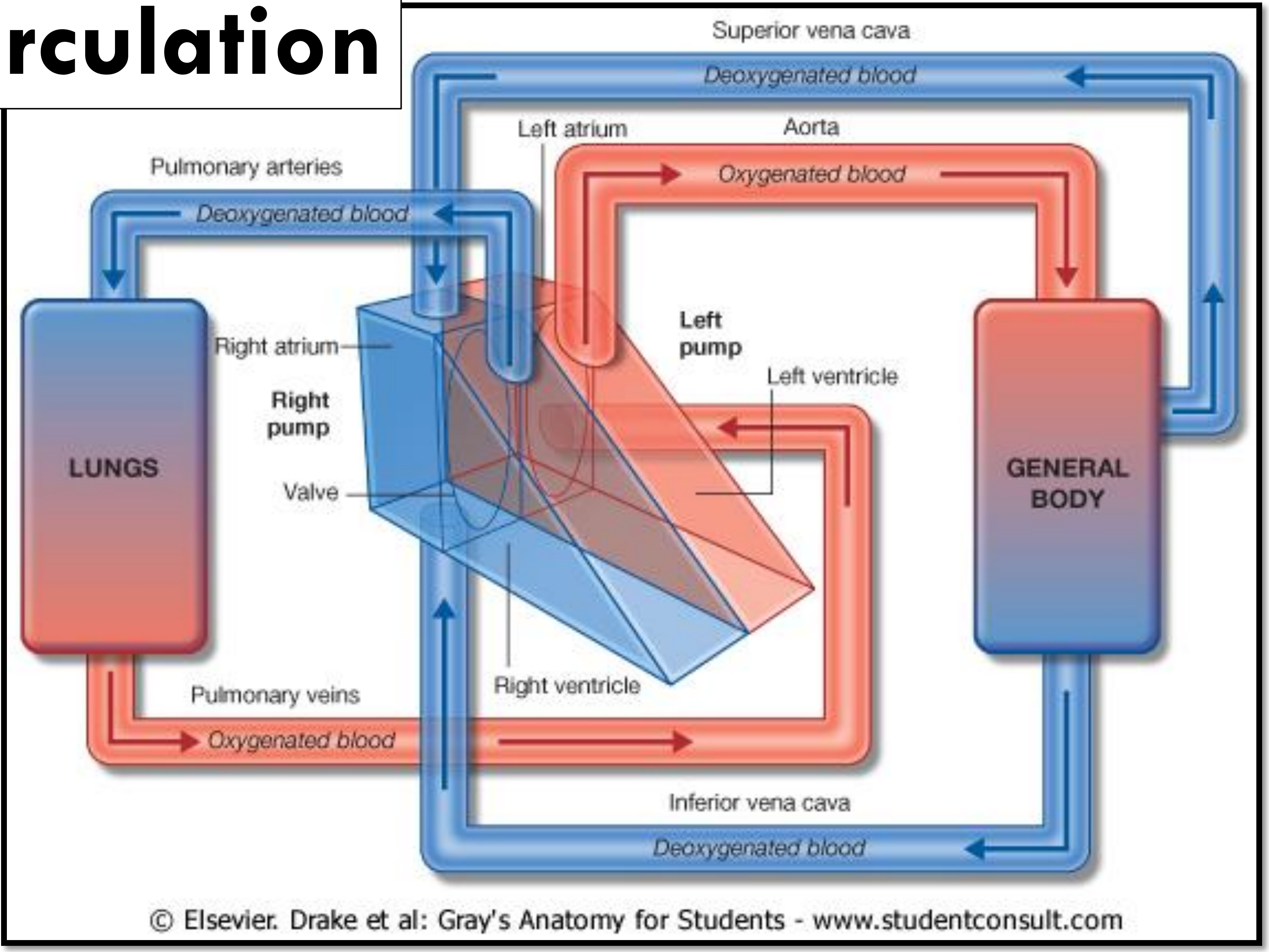
Circulation



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The Apex Of The Heart

- Is formed by the inferolateral part of the left ventricle.
- Is where the sounds of mitral valve closure are maximal (apex beat).

Apex Of The Heart

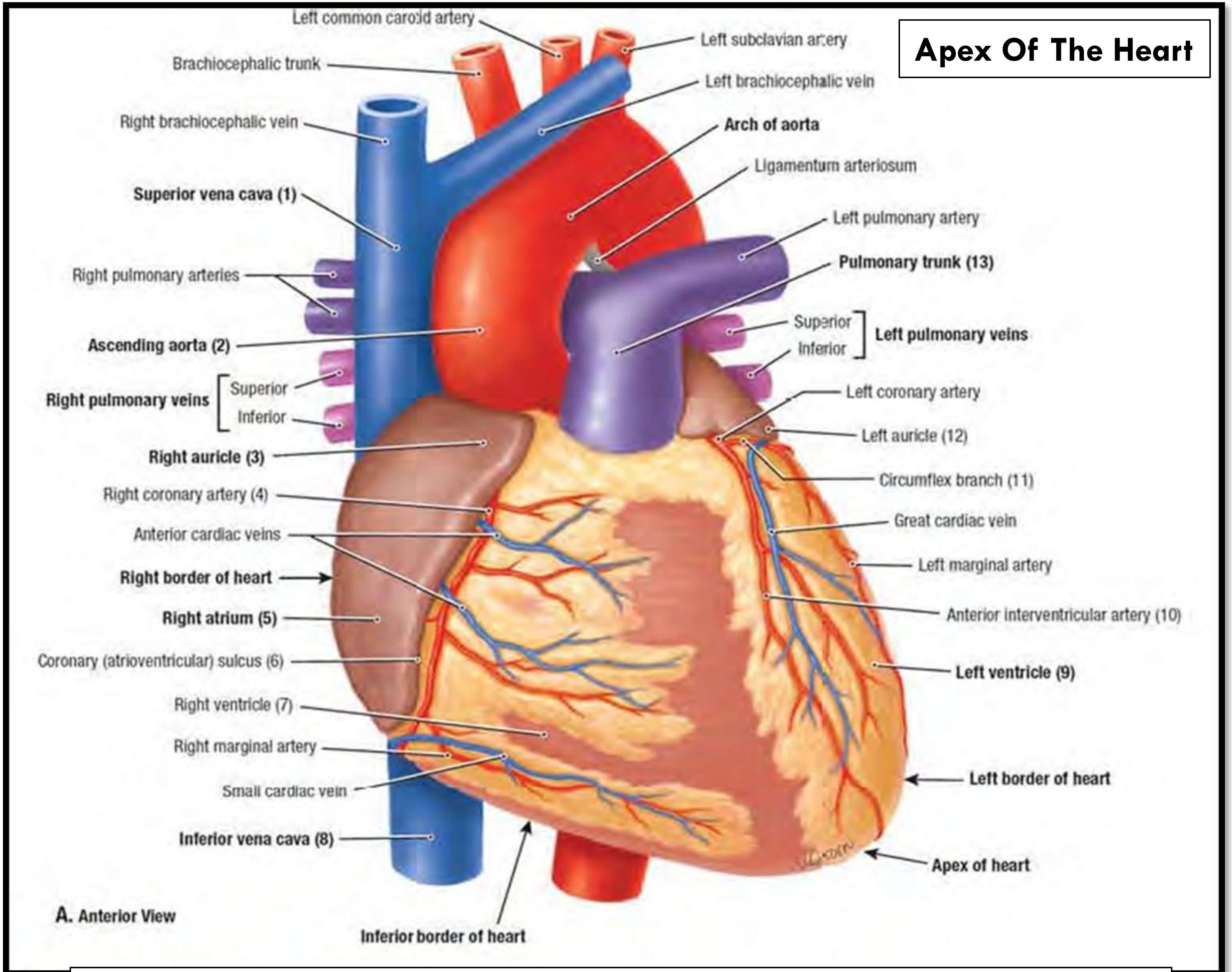


Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

The Base Of The Heart

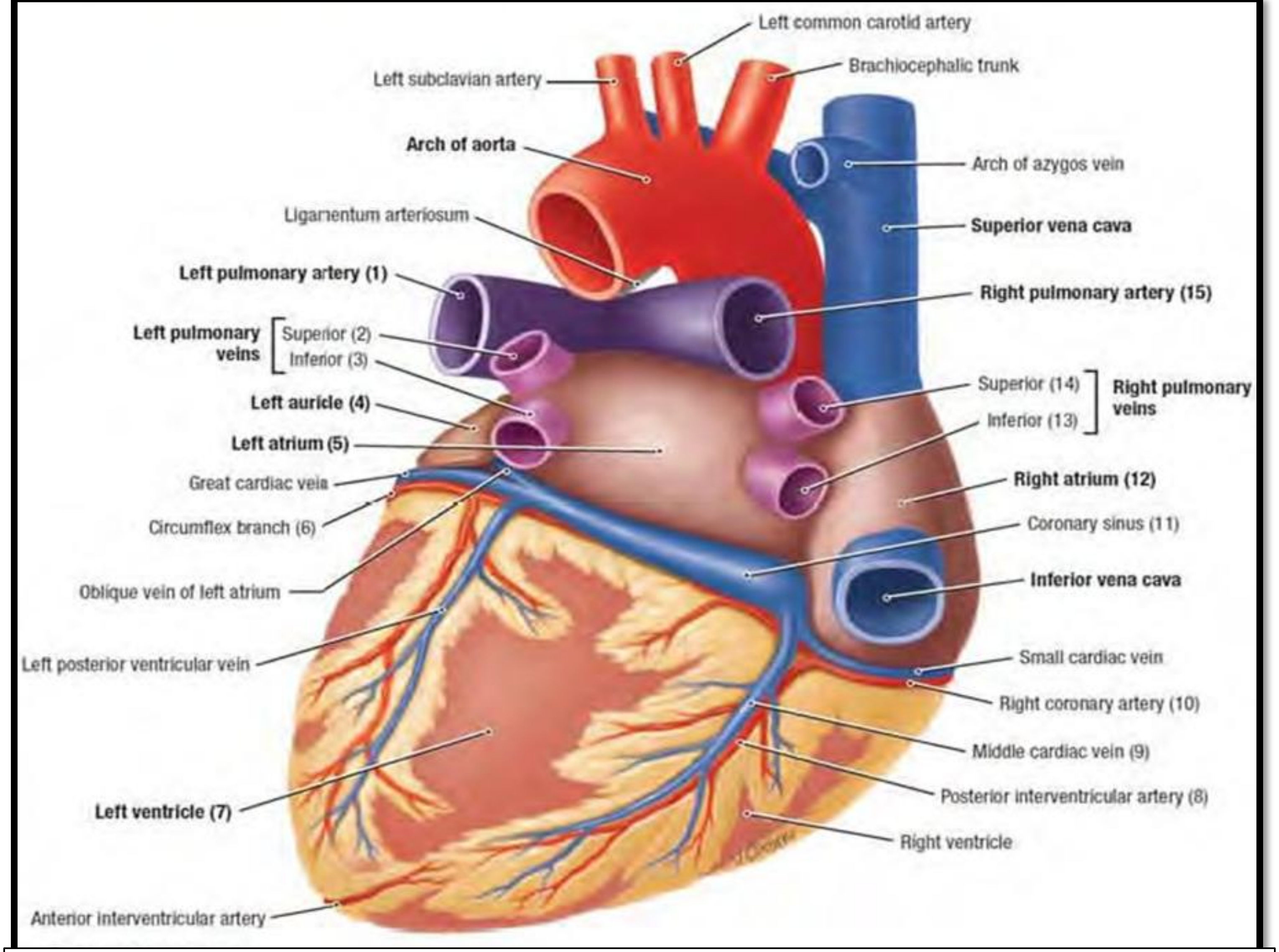
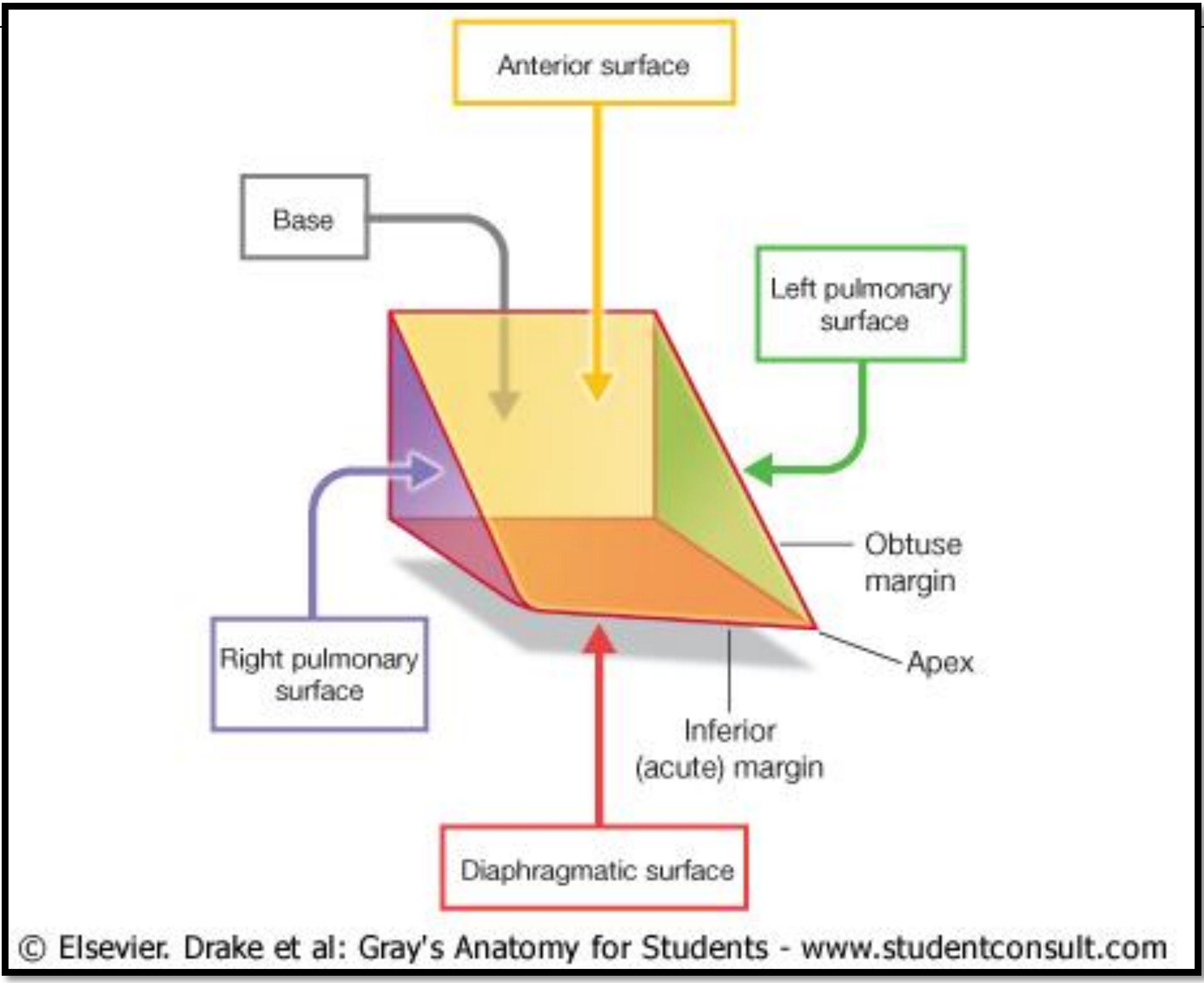


Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

The Base Of The Heart

- Is the heart's posterior aspect (opposite the apex).
- Is formed mainly by the left atrium.
- Faces posteriorly toward the bodies of vertebrae T6 to T9 , separated from them by the esophagus and aorta.

The Surfaces Of The Heart



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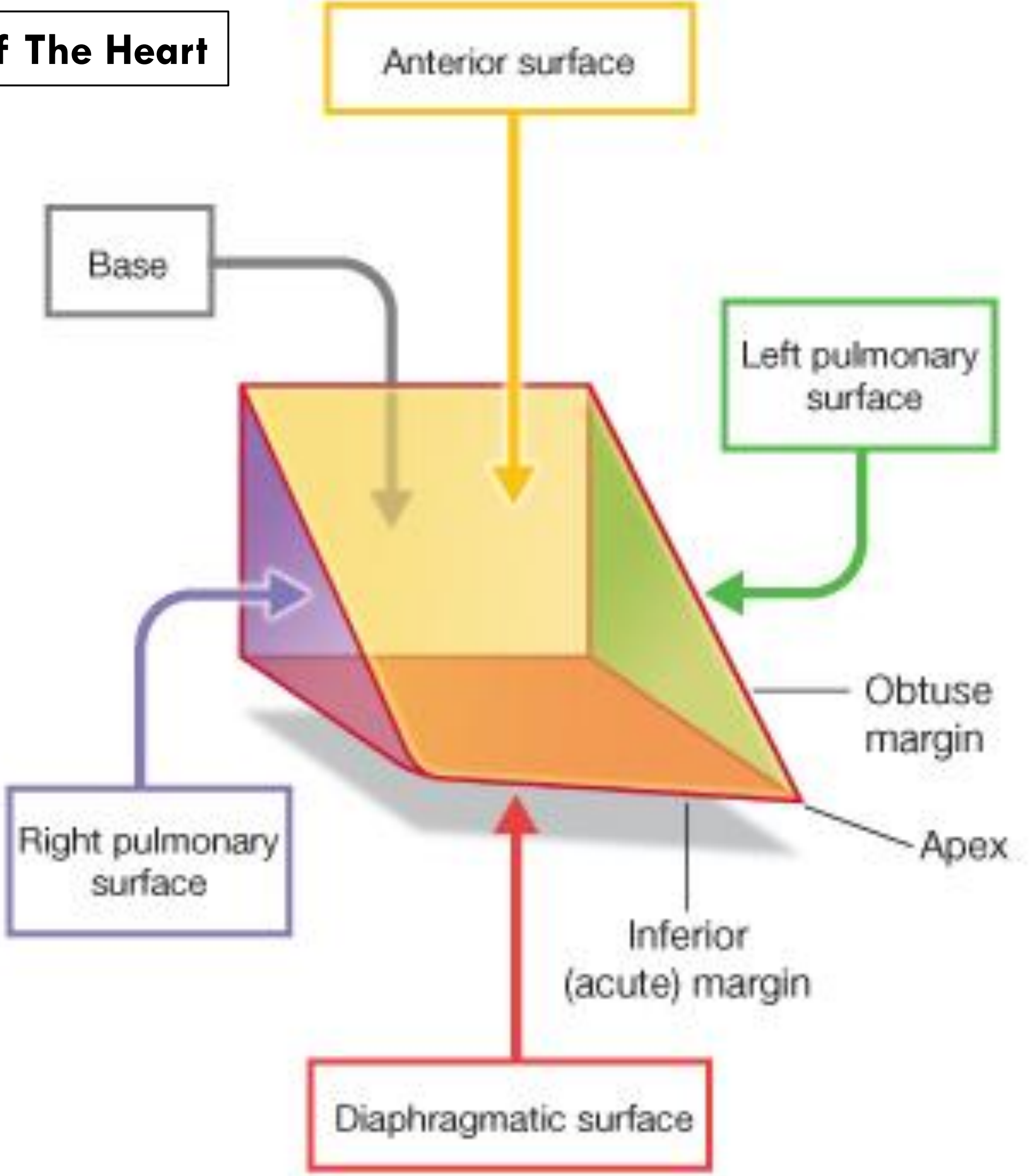
The Surfaces Of The Heart

- **Anterior (sternocostal) surface.**
  - Formed mainly by the right ventricle.
- **Diaphragmatic (inferior) surface.**
  - Formed mainly by the left ventricle.

Surfaces Of The Heart



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The Borders Of The Heart

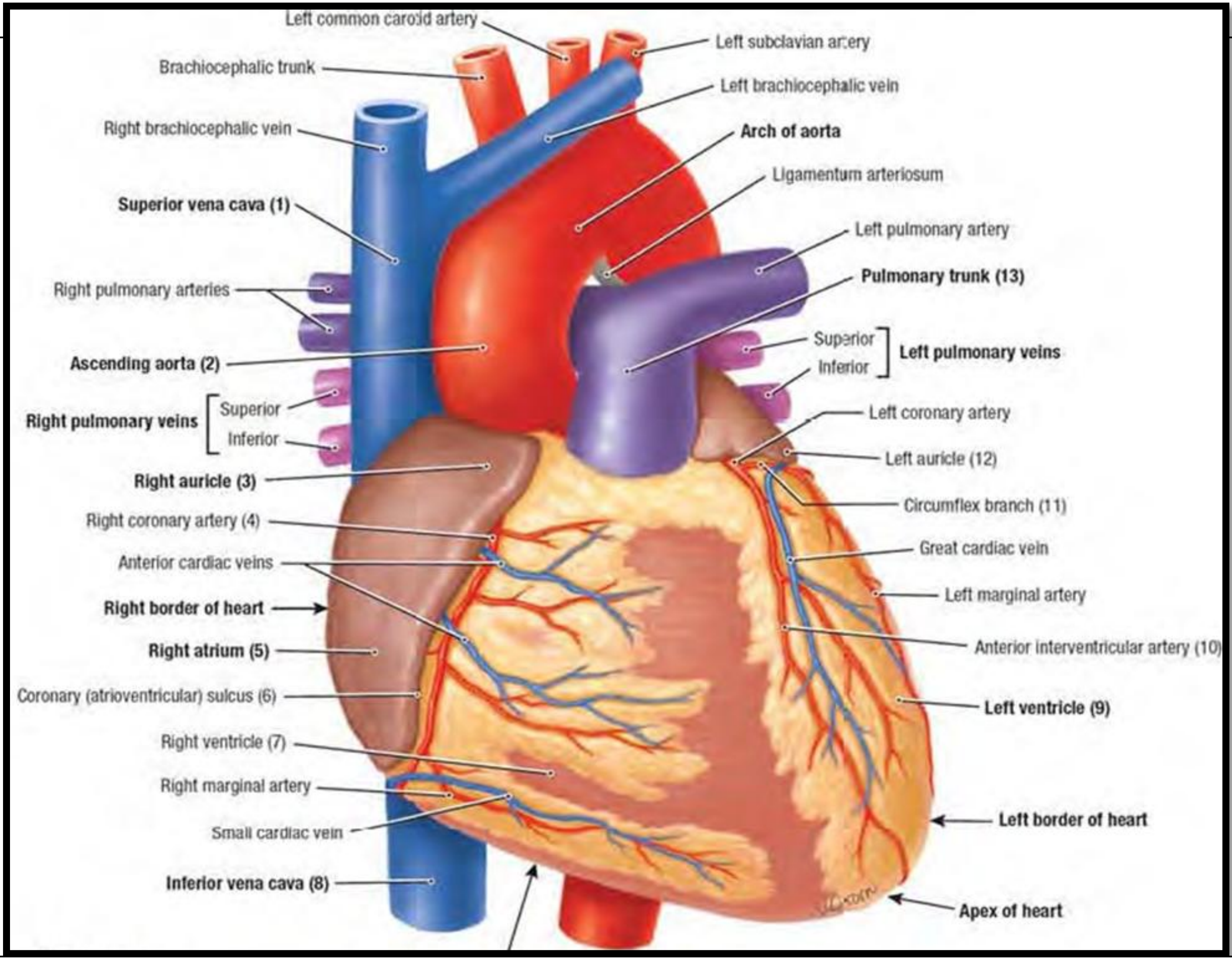


Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

The Borders Of The Heart (1)

- **Right border:**
  - Formed by the right atrium and extending between the SVC and the IVC.
- **Inferior border:**
  - Formed mainly by the right ventricle and slightly by the left ventricle.

The Borders Of The Heart

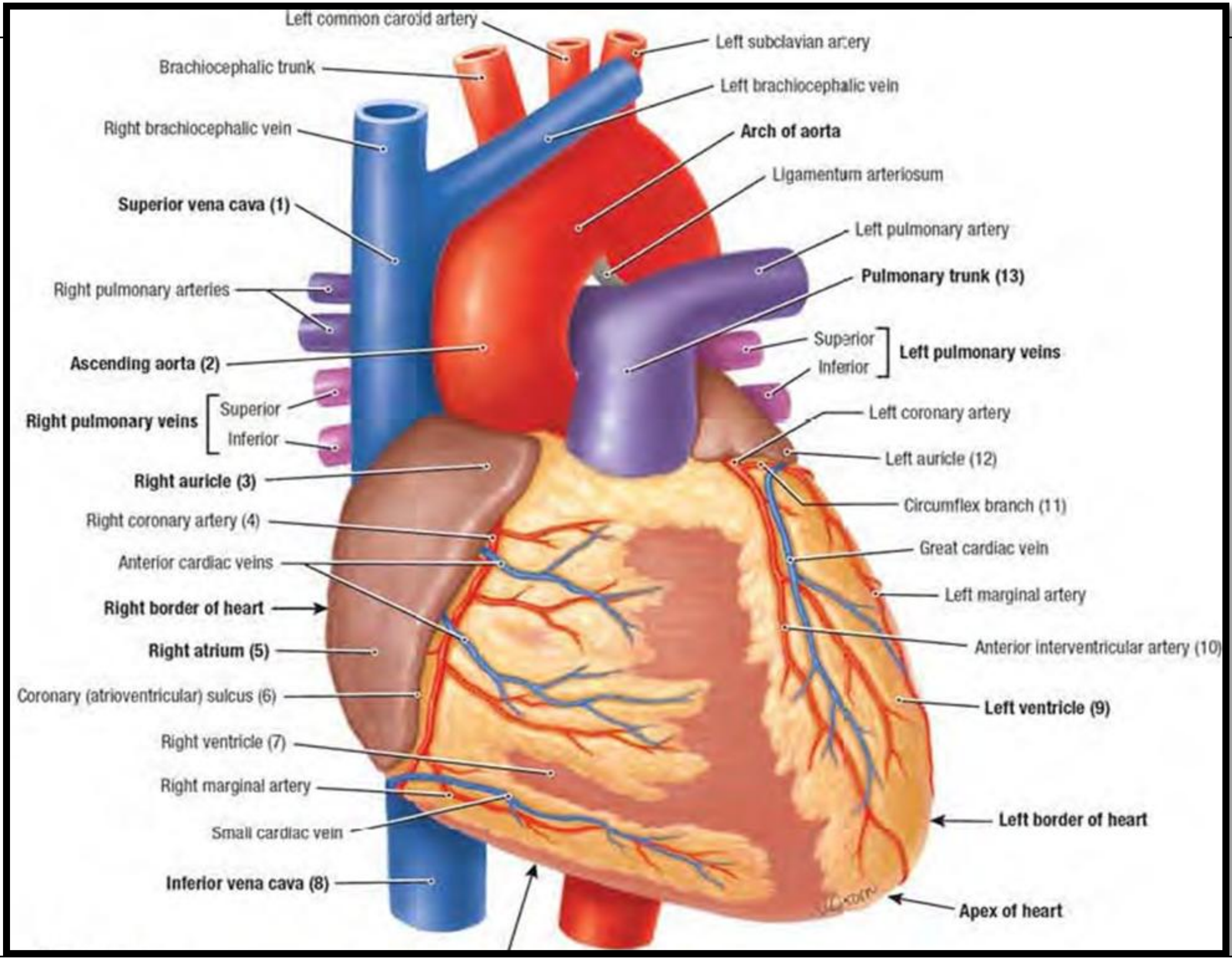


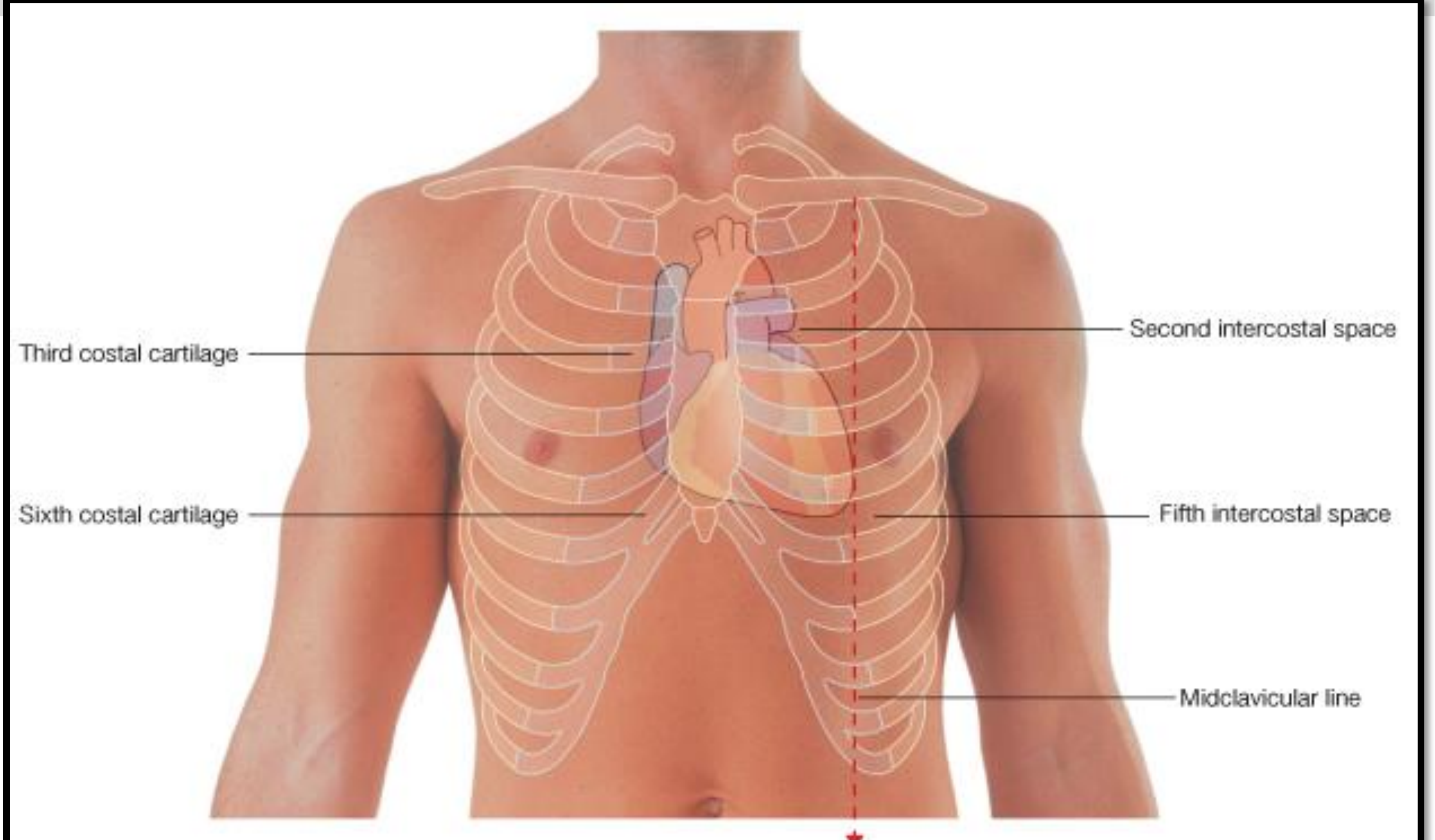
Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

The Borders Of The Heart (2)

- **Left border:**
  - Formed mainly by the left ventricle and slightly by the left auricle.
- **Superior border:**
  - Formed by the right and left atria and auricles in an anterior view.

Surface anatomy: borders of the heart (see the next slides from 1 to 5)

(1) The superior border corresponds to a line connecting the inferior border of the 2nd left costal cartilage to the superior border of the 3rd right costal cartilage.



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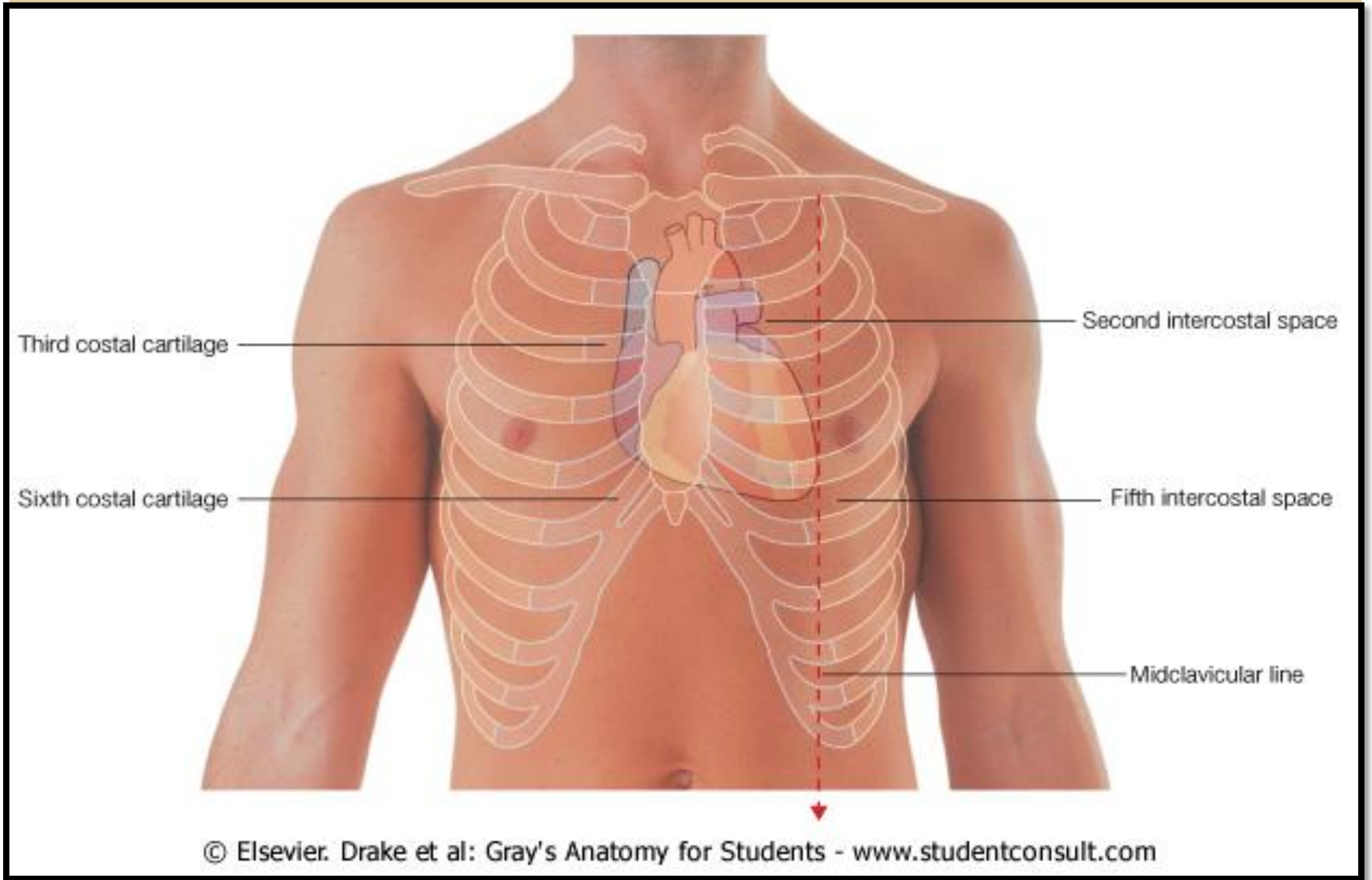
(2) The right border corresponds to a line drawn from the 3rd right costal cartilage to the 6th right costal cartilage; this border is slightly convex to the right.



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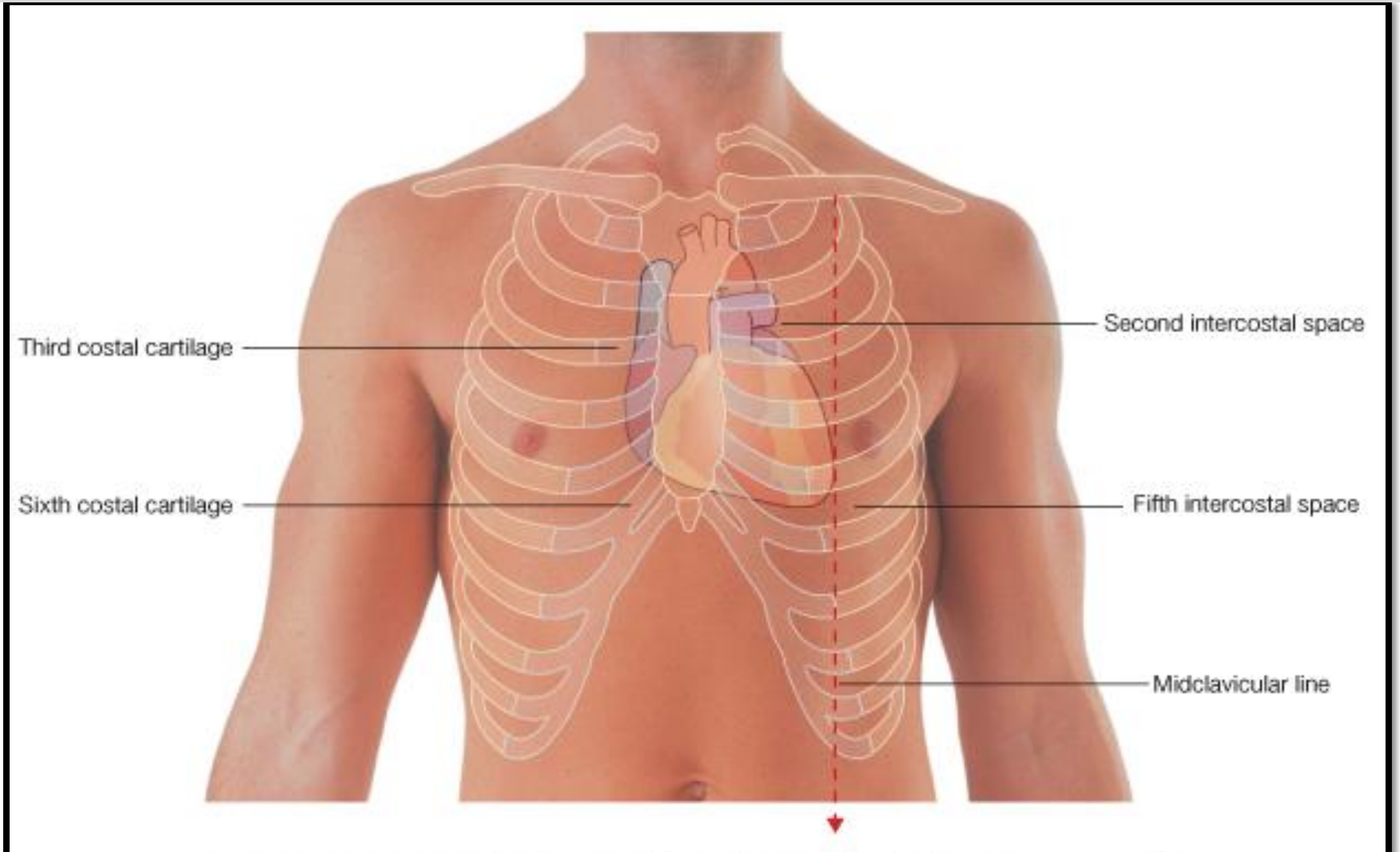
(3) The inferior border corresponds to a line drawn from the inferior end of the right border to a point in the 5th intercostal space close to the left MCL.



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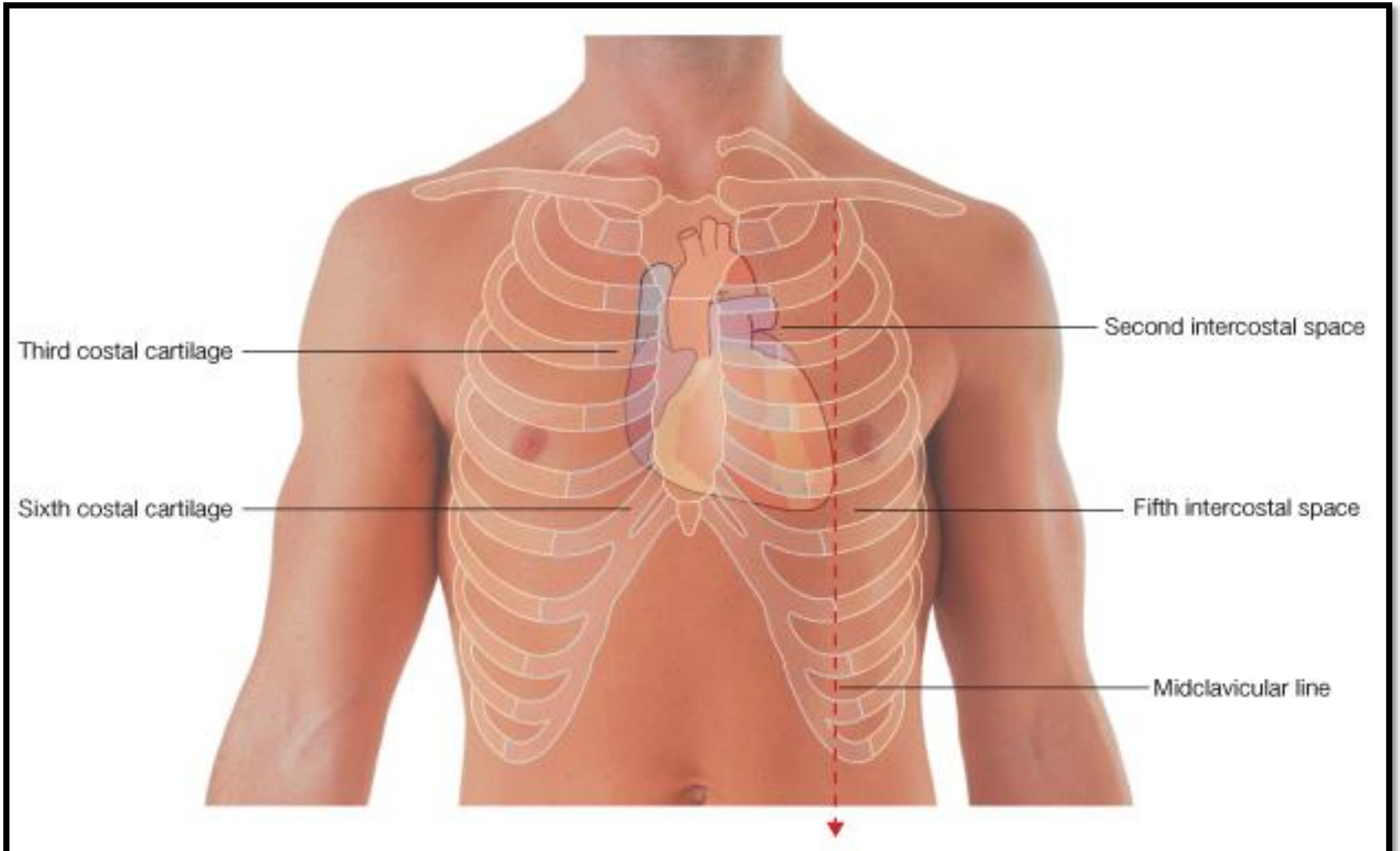
(4) The left border corresponds to a line connecting the left ends of the lines representing the superior and inferior borders.



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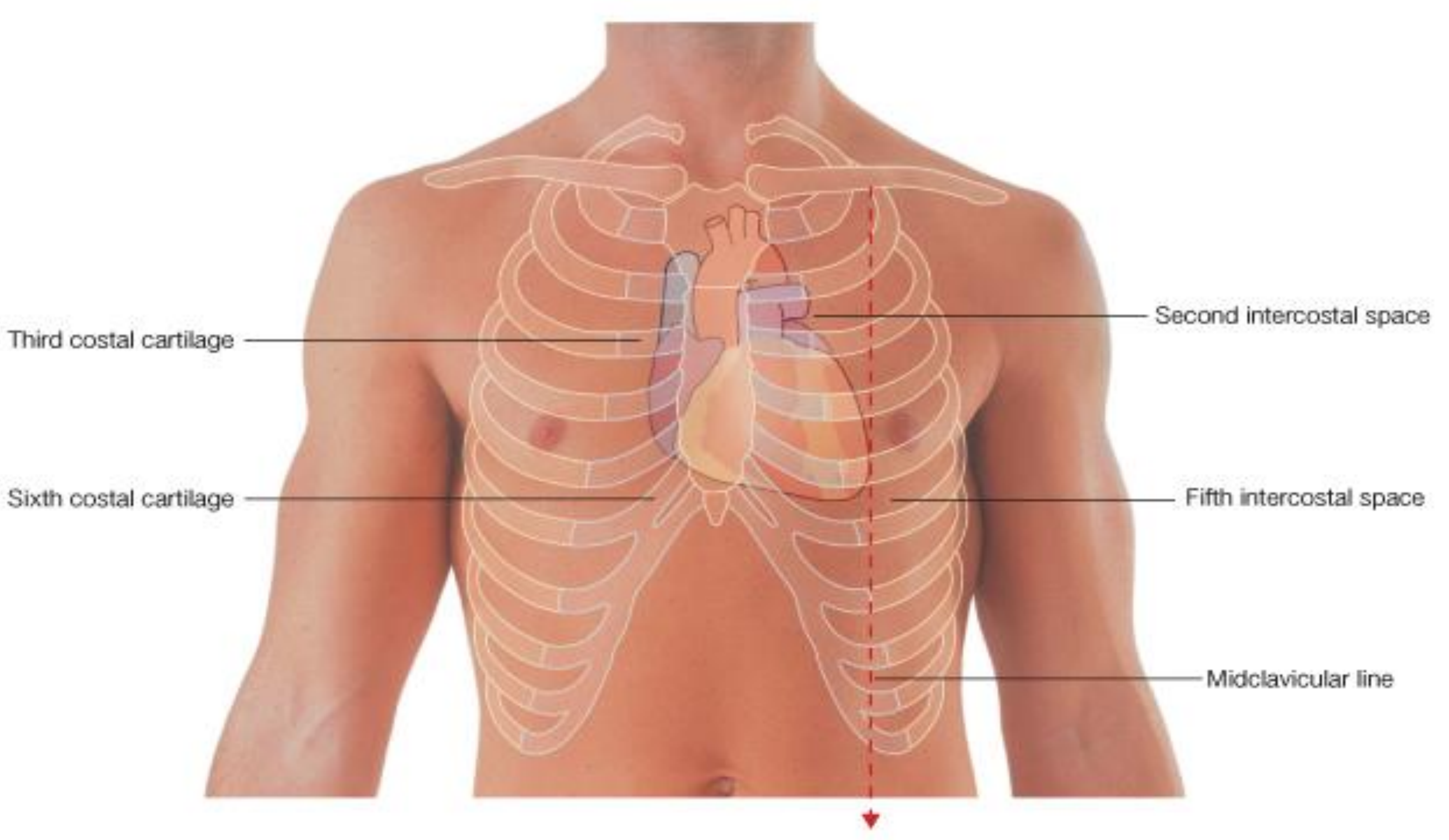
(5) The apex of the heart: at the junction of the midclavicular line and 5th intercostal space.



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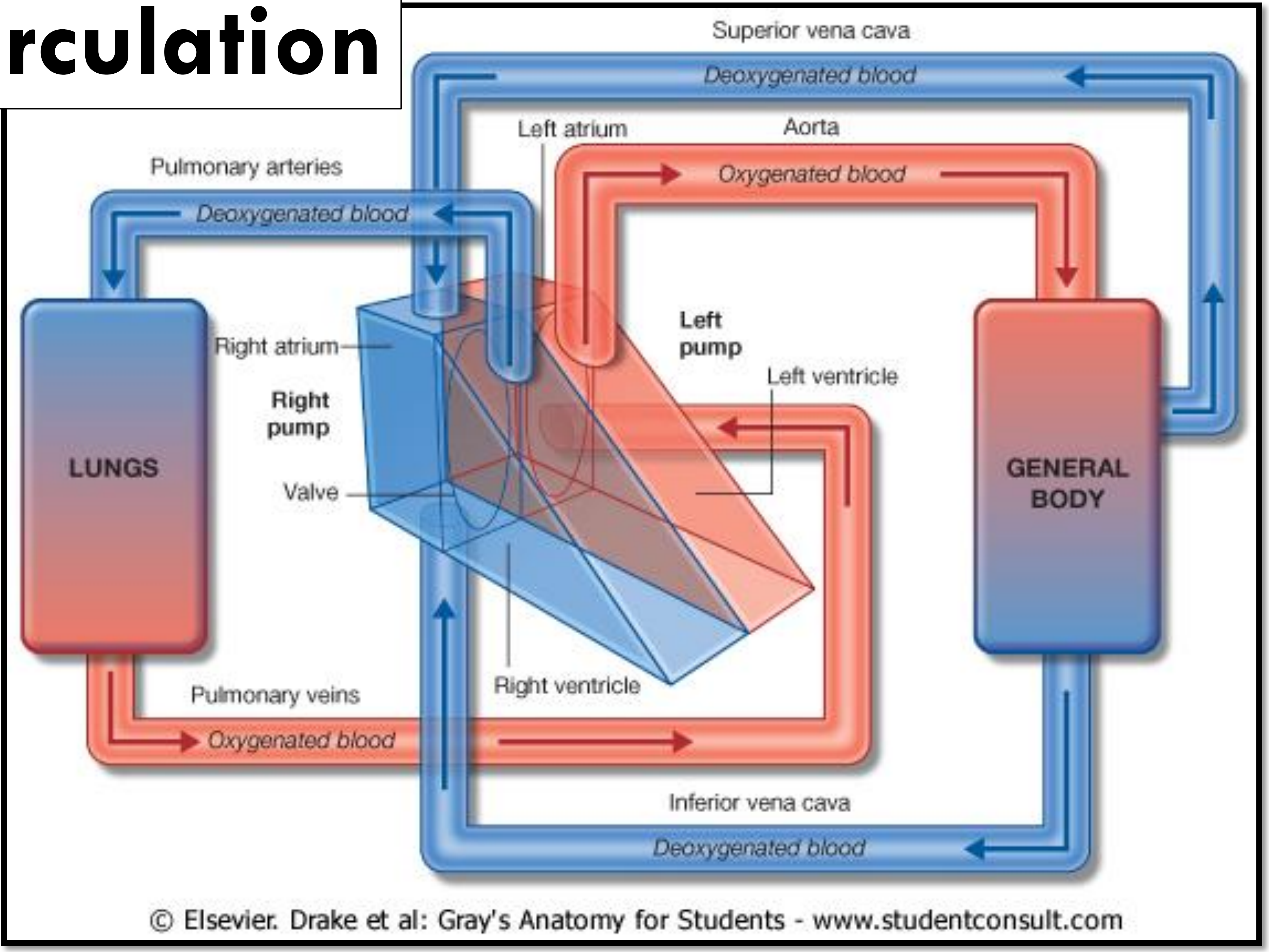
Lecture's map

- Pericardium.
- **Heart:**
  - Surfaces and borders.
  - **Valves.**
  - **Champers.**

Circulation



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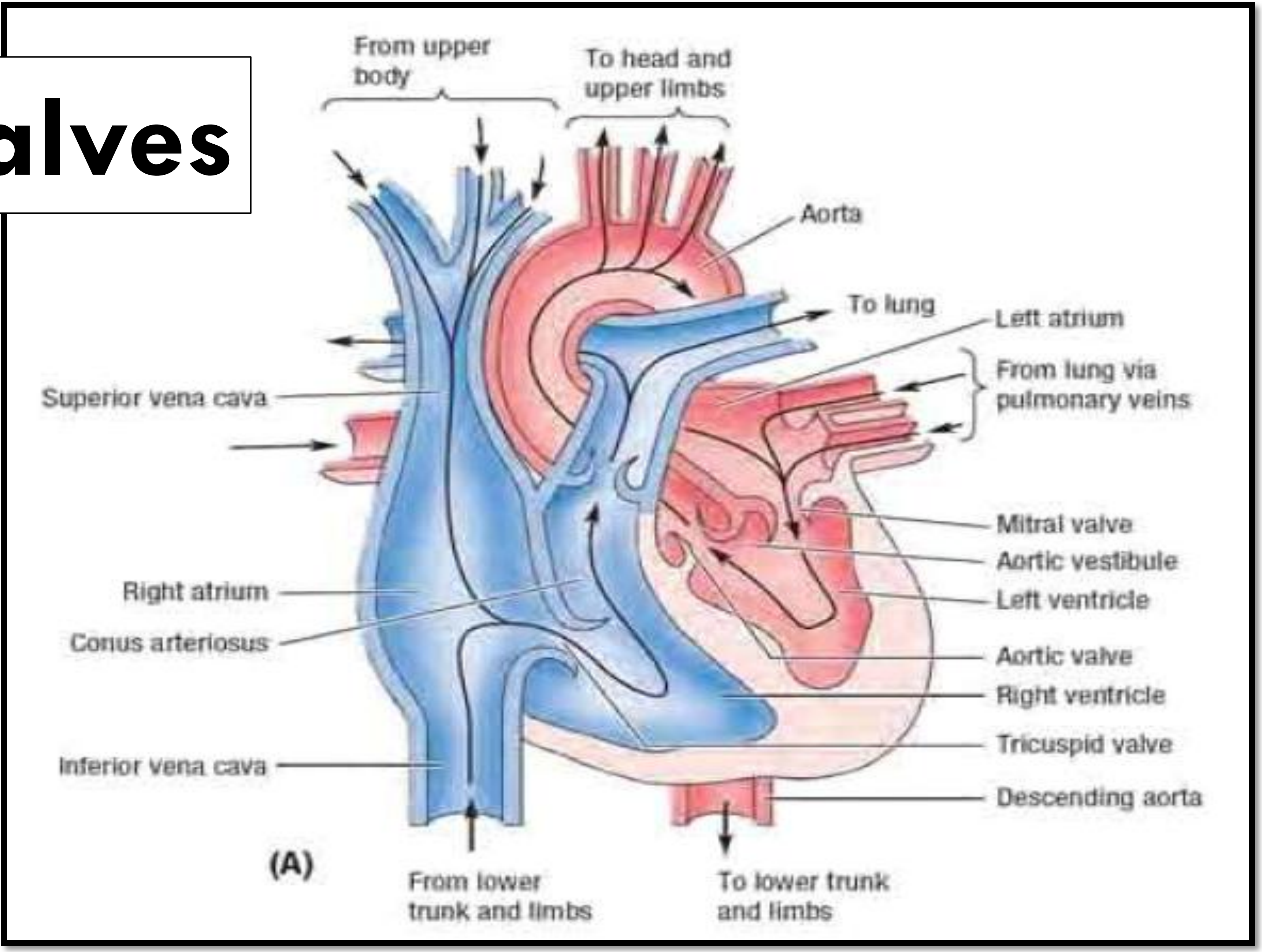
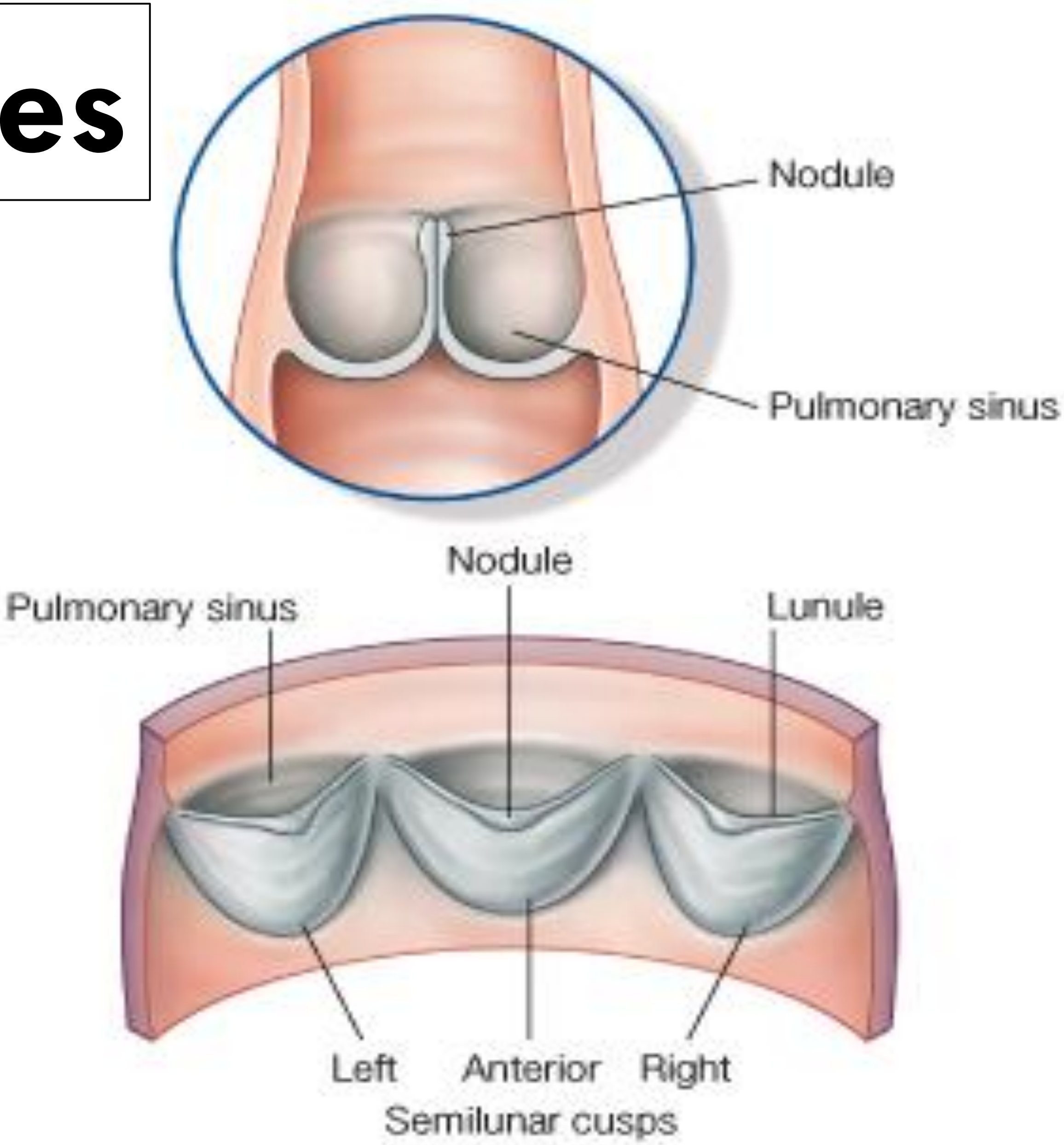
Valves and Vessels

- **Tricuspid valve (Tricuspid):**
  - Blood flows from right atrium to right ventricle.
- **Pulmonary valve(Tricuspid):**
  - Blood flows from the right ventricle to the pulmonary trunk.
- **Mitral valve (Bicuspid):**
  - Blood flows from the left atrium to the left ventricle.
- **Aortic valve (Tricuspid):**
  - Blood flows from the left ventricle to the aorta.

Valves


From upper body
To head and upper limbs
Aorta
To lung
Left atrium
From lung via pulmonary veins
Superior vena cava
Mitral valve
Aortic vestibule
Right atrium
Left ventricle
Conus arteriosus
Aortic valve
Right ventricle
Tricuspid valve
Inferior vena cava
Descending aorta
(A)
From lower trunk and limbs
To lower trunk and limbs

Valves



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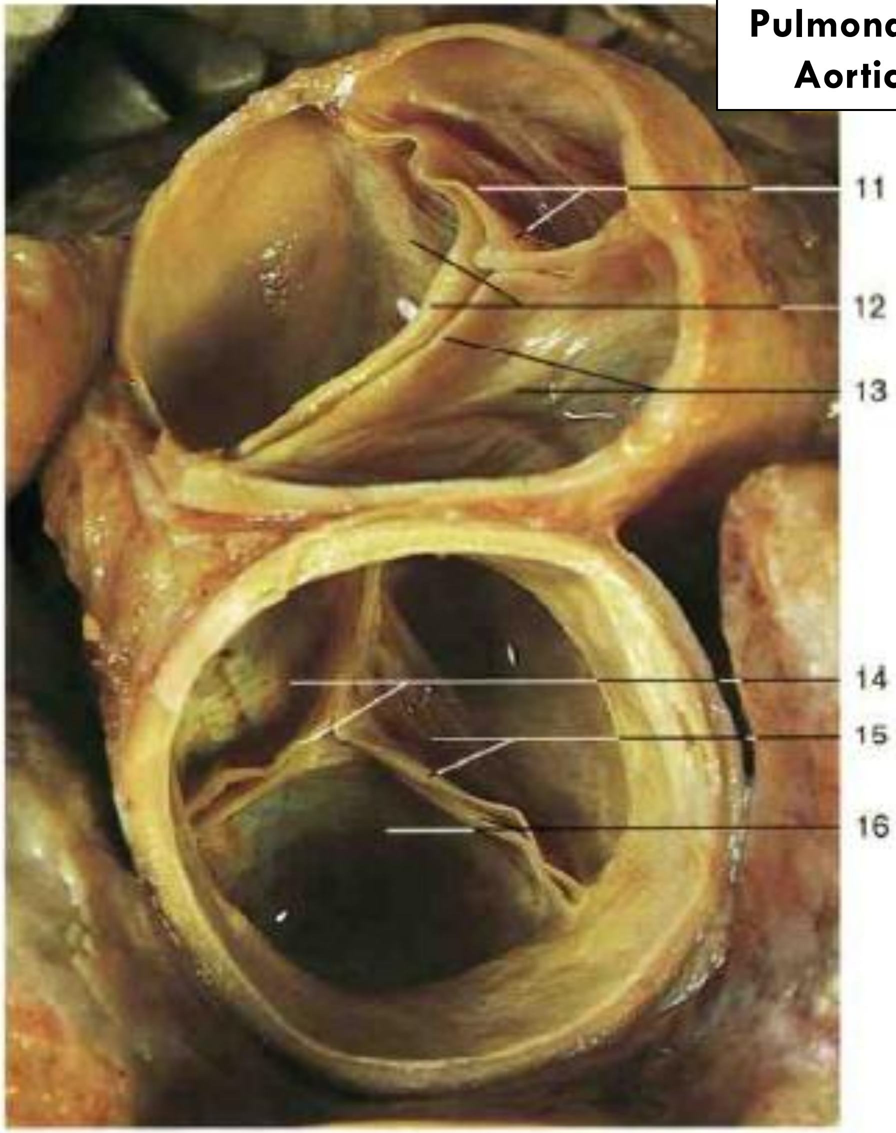
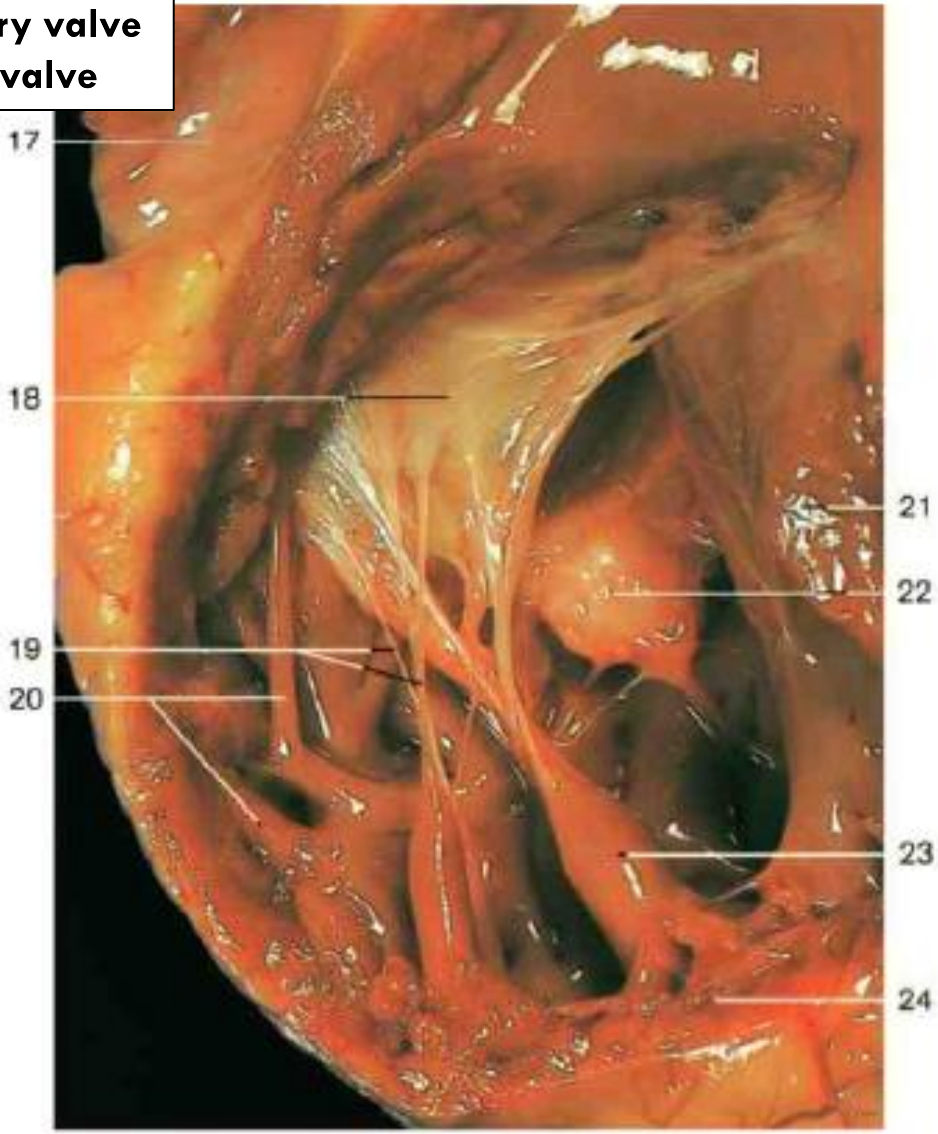
Tricuspid valve
Pulmonary valve
Aortic valve



Pulmonic and aortic valves (from above). Anterior wall of the heart at the top. Both valves are closed.



Right atrioventricular (tricuspid) valve (anterior aspect after removal of the anterior wall of the right ventricle).

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

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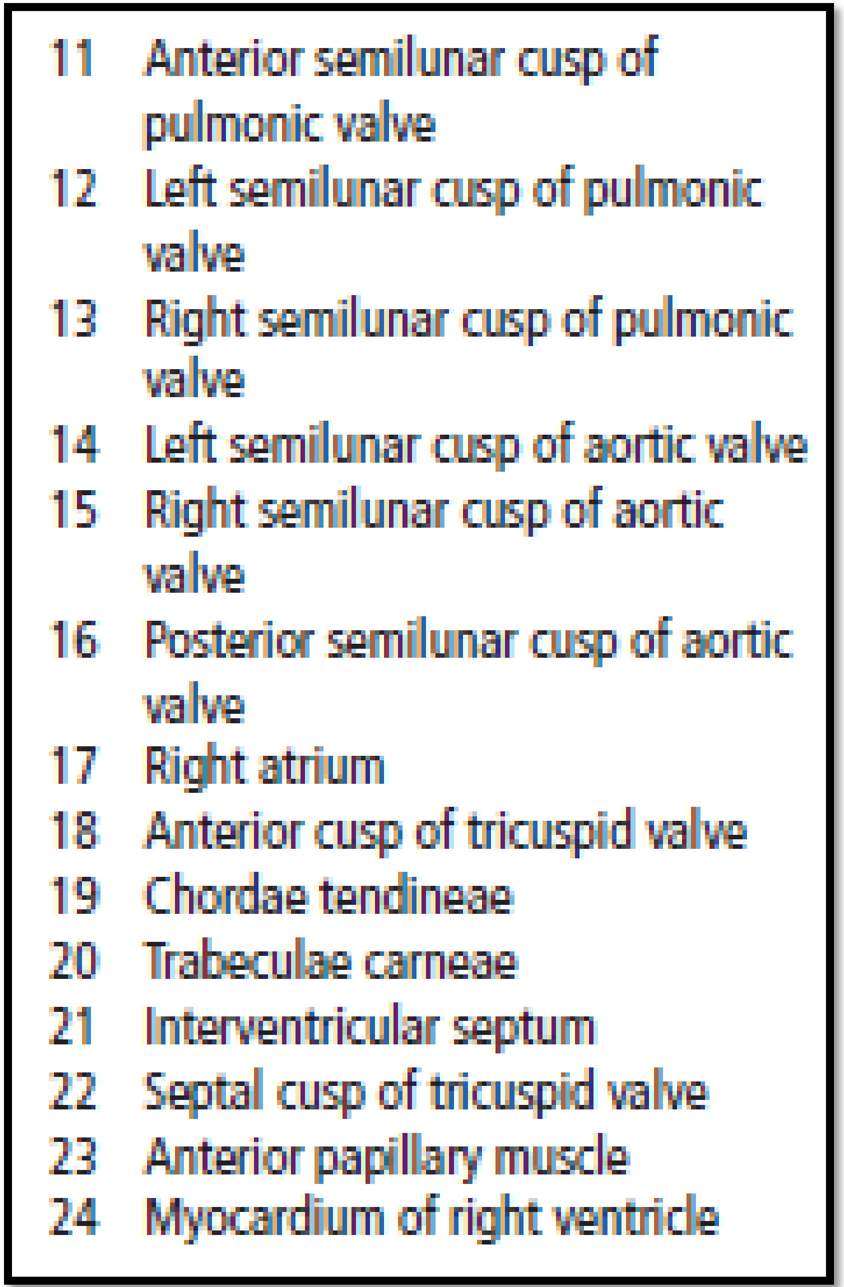
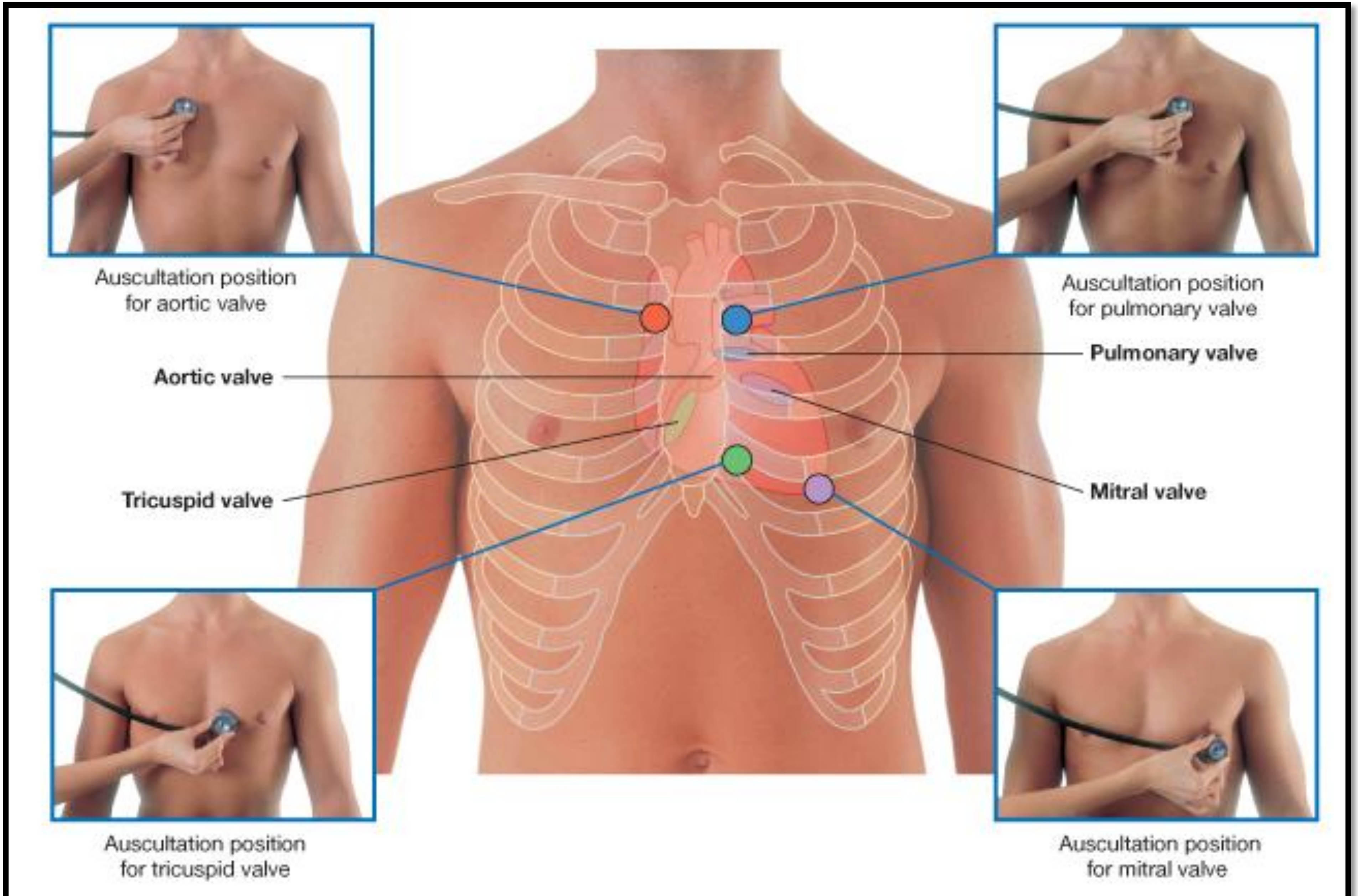


11	Anterior semilunar cusp of pulmonic valve
12	Left semilunar cusp of pulmonic valve
13	Right semilunar cusp of pulmonic valve
14	Left semilunar cusp of aortic valve
15	Right semilunar cusp of aortic valve
16	Posterior semilunar cusp of aortic valve
17	Right atrium
18	Anterior cusp of tricuspid valve
19	Chordae tendineae
20	Trabeculae carneae
21	Interventricular septum
22	Septal cusp of tricuspid valve
23	Anterior papillary muscle
24	Myocardium of right ventricle

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

Surface anatomy: Where to listen for heart sounds (Also see the next slide)

- The tricuspid valve : just to the left of the lower part of the sternum near the 5th intercostal space.
- The mitral valve : over the apex of the heart in the left 5th intercostal space at the midclavicular line.
- The pulmonary valve : over the medial end of the left 2nd intercostal space.
- The aortic valve : over the medial end of the right 2nd intercostal space.


Auscultation position for aortic valve
Auscultation position for pulmonary valve
Pulmonary valve
Aortic valve
Tricuspid valve
Mitral valve
Auscultation position for tricuspid valve
Auscultation position for mitral valve

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Think about this

- Nadia is 45 years old housewife, presented to the E.R with weakness in her left arm, during physical examination the resident doctor noticed that The S1 sound is loud and followed by an opening snap (OS), she mentioned that she was suffering from difficulty in breathing when performing any physical exercise (exertional dyspnea).
- After workup, the doctor made the diagnosis of ischemic stroke following mitral stenosis; an immediate treatment policy has been put into action.

Now try to answer these questions about the previous story:

- Describe the anatomy of the mitral valve.
- Mention the surface marking of this valve.
- Where is the best point to listen to the sounds of this valve in auscultation?
- What are the meaning of the following terms: stenosis, ischemic stroke and exertional dyspnea?
- How does mitral stenosis cause ischemic stroke?

Fibrous skeleton

- ☐ This is a complex framework of dense collagen forming four fibrous rings that surround the orifices of the valves.

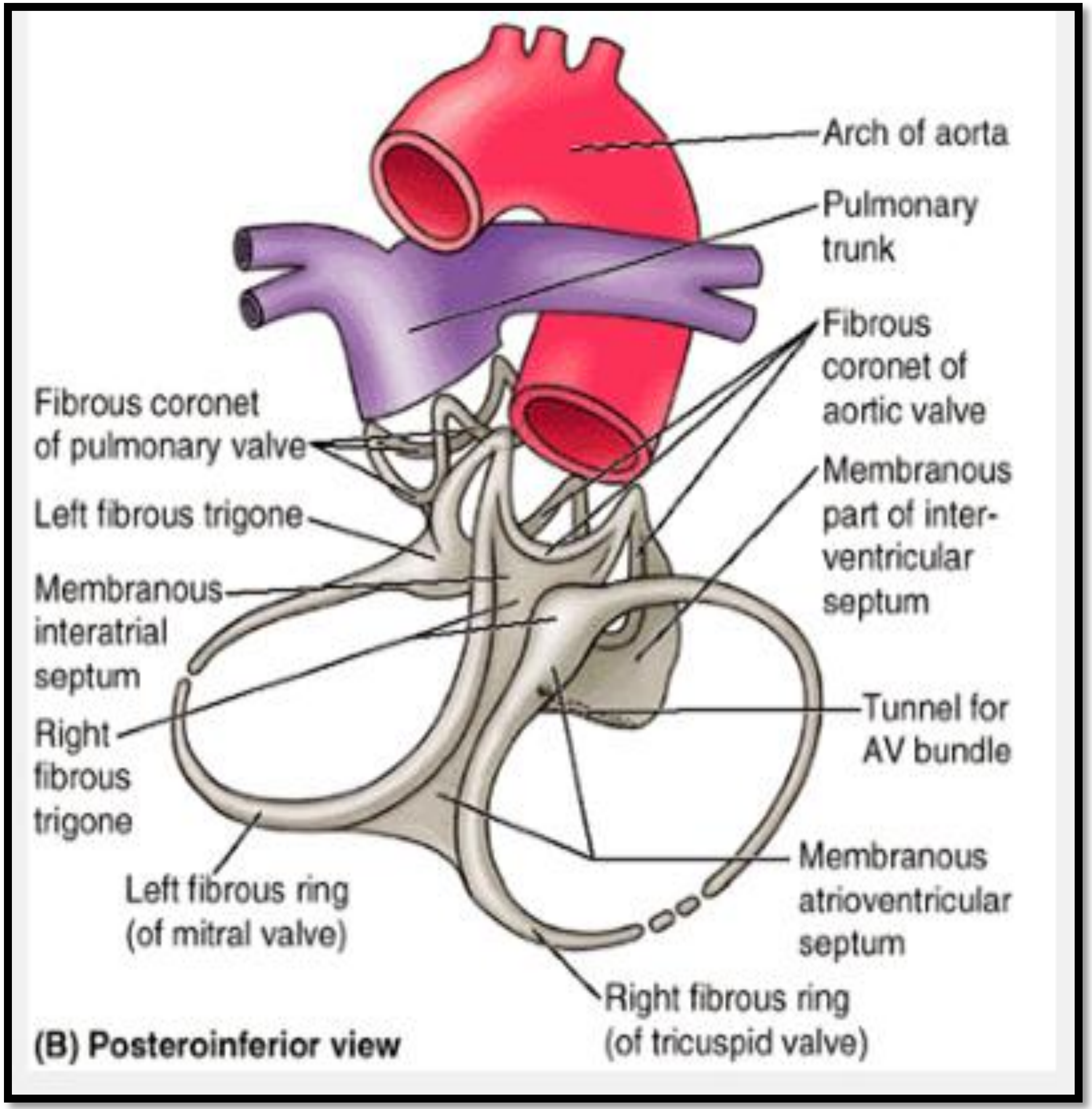

Arch of aorta
Pulmonary trunk
Fibrous coronet of aortic valve
Membranous part of inter-ventricular septum
Tunnel for AV bundle
Membranous atrioventricular septum
Right fibrous ring (of tricuspid valve)
Fibrous coronet of pulmonary valve
Left fibrous trigone
Membranous interatrial septum
Right fibrous trigone
Left fibrous ring (of mitral valve)
(B) Posteroinferior view

Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

Lecture's map

- Pericardium.
- **Heart:**
  - Surfaces and borders.
  - Valves.
  - **Champers.**

The Champers Of The Heart

- **Four champers:**
  - **Right atrium.**
  - **Right ventricle.**
  - **Left atrium.**
  - **Left ventricle.**

Right Atrium

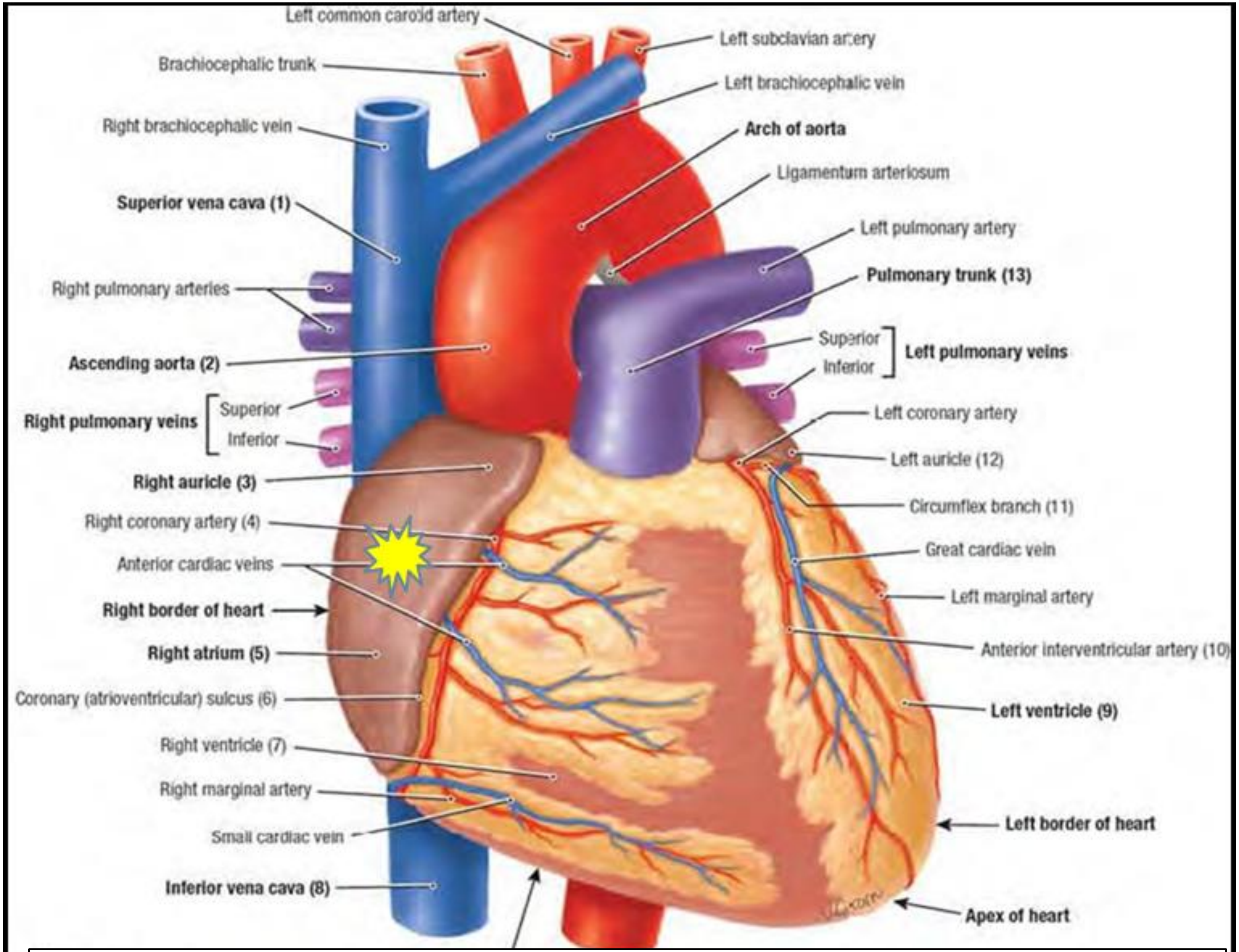
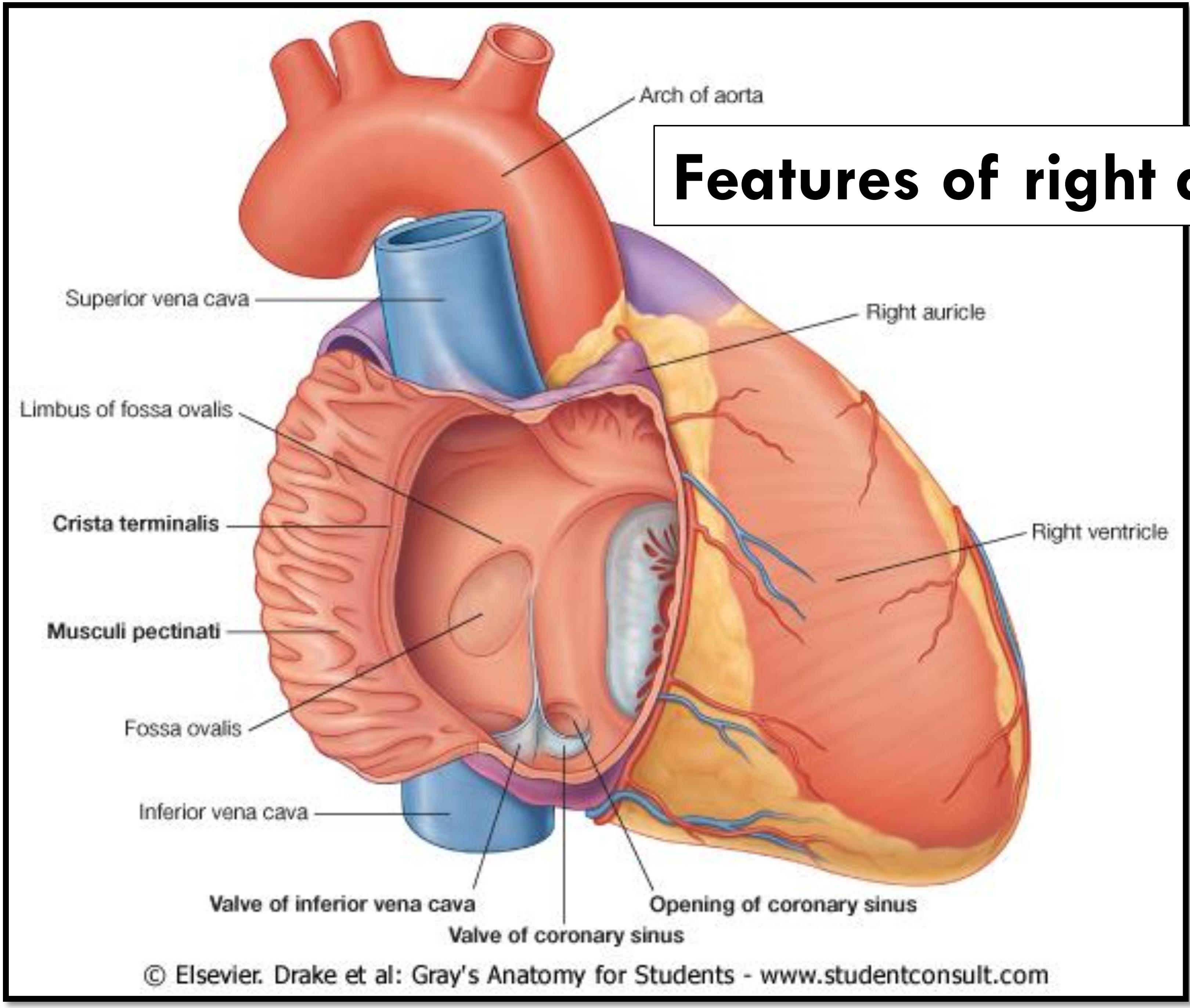


Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12^{th} Ed. Lippincott Williams & Wilkins; 2009.

Right Atrium (1)

- **Features:**
  - Sulcus terminalis or terminal groove , and internally by a vertical ridge, the crista terminalis or terminal crest .
  - Right Auricle (rough-walled).
  - The SVC opens into the superior part of the right atrium.
  - The IVC opens into the inferior part.

Features of right atrium



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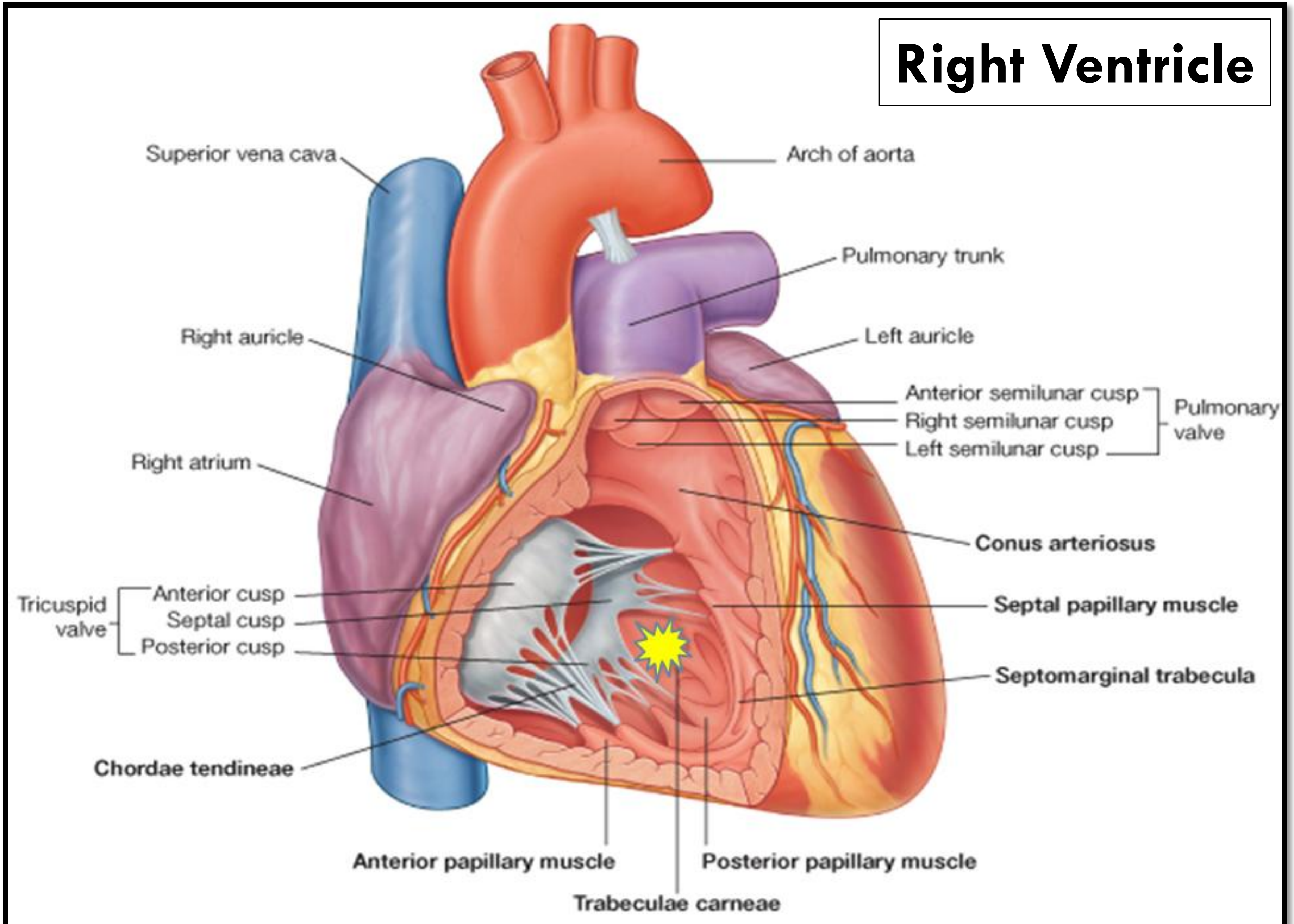
Right Atrium (2)

- **Features:**
  - The opening of the coronary sinus: it is between the AV orifice and the IVC orifice.
  - The oval fossa (L. fossa ovalis): it is a remnant of the foramen ovale in the fetus.
  - Interatrial septum.

Right Ventricle (1)

- **Features:**
  - The right AV orifice (tricuspid valve).
  - Muscles.
  - Interventricular septum (IVS).

Right Ventricle



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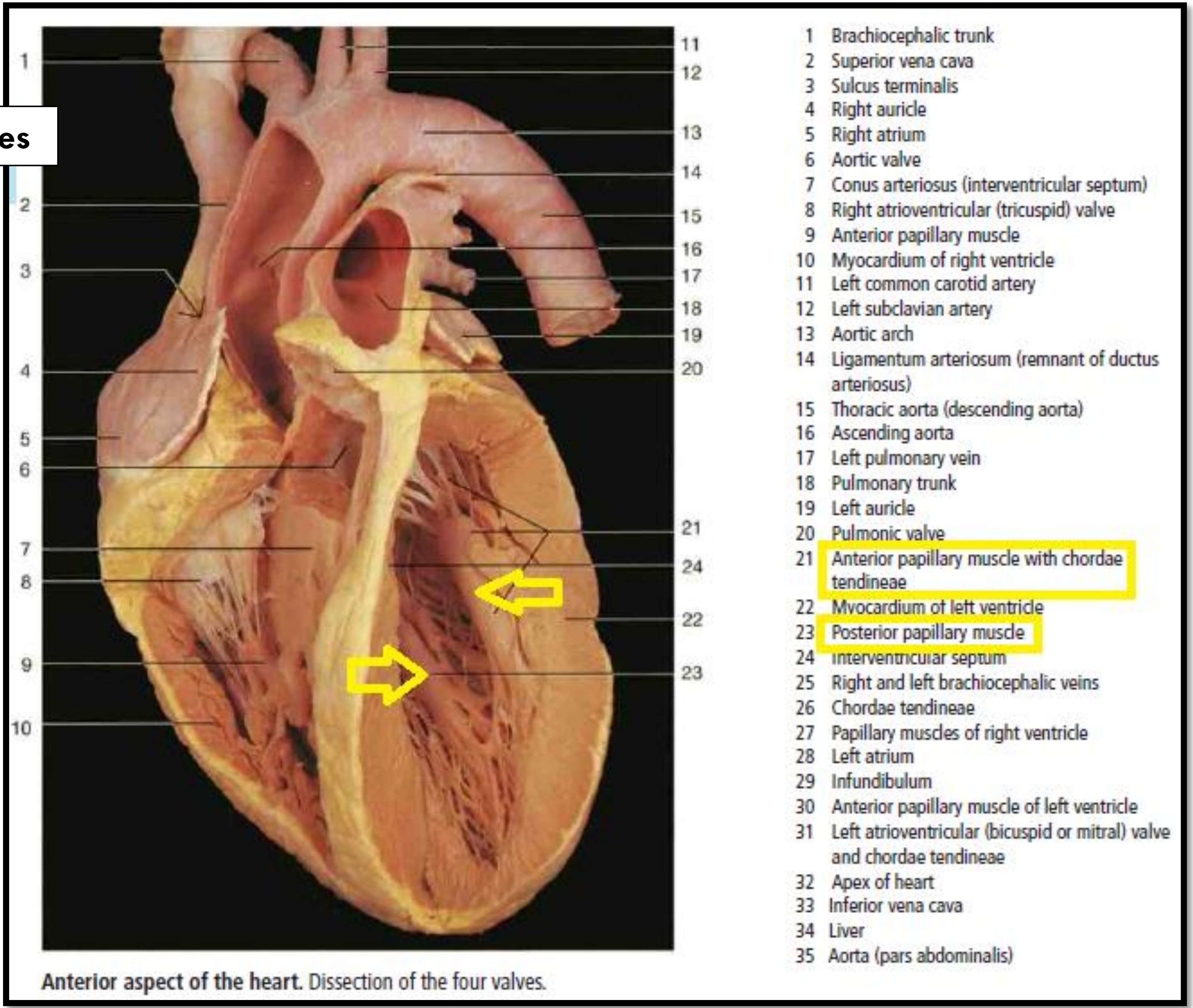
Right Ventricle (2)

- **Muscles:**
  - Trabeculae carneae (irregular muscular elevations).
  - Septomarginal trabecula (moderator band).
  - Papillary muscles (have base and apex).
  - Chordae tendineae (link the Papillary muscles to the cusps).

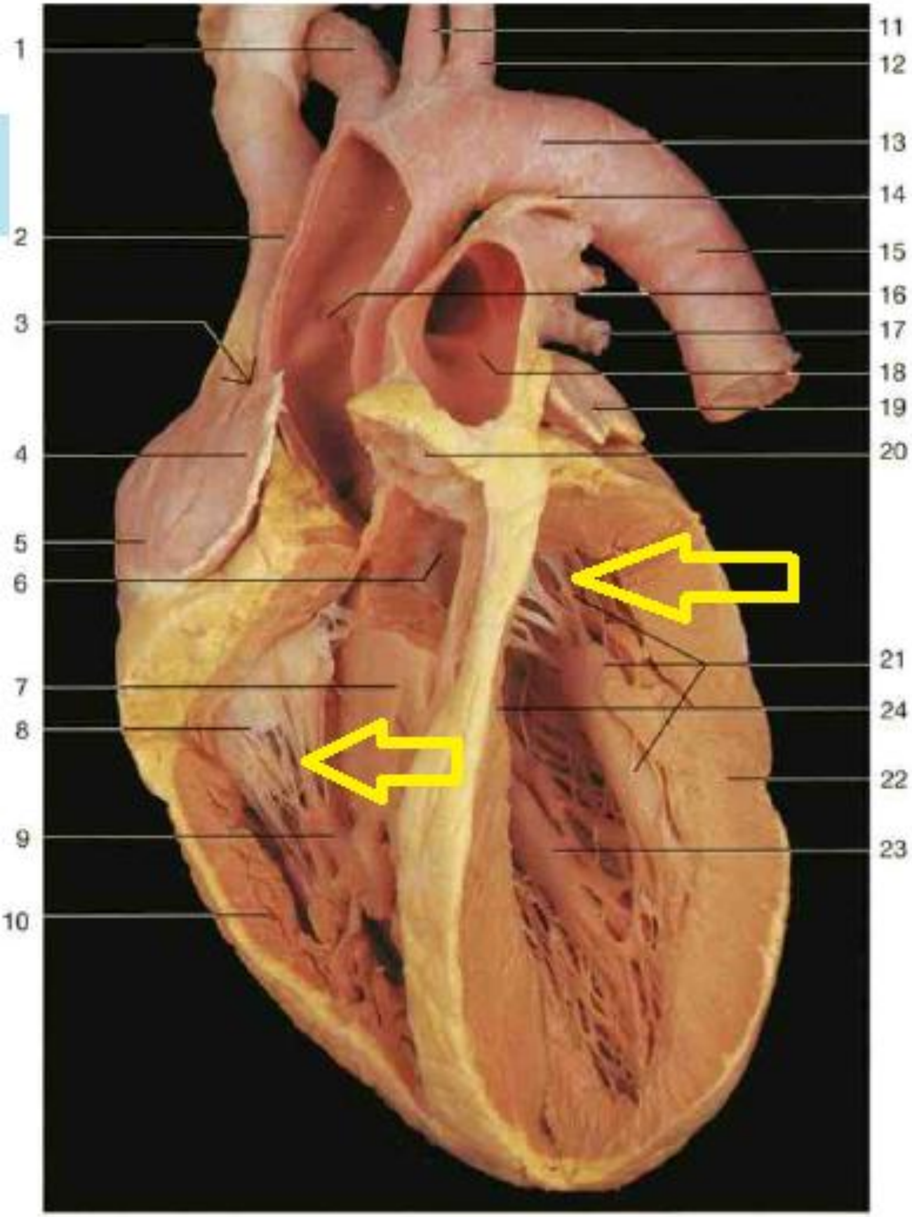
Papillary muscles



1 Brachiocephalic trunk
2 Superior vena cava
3 Sulcus terminalis
4 Right auricle
5 Right atrium
6 Aortic valve
7 Conus arteriosus (interventricular septum)
8 Right atrioventricular (tricuspid) valve
9 Anterior papillary muscle
10 Myocardium of right ventricle
11 Left common carotid artery
12 Left subclavian artery
13 Aortic arch
14 Ligamentum arteriosum (remnant of ductus arteriosus)
15 Thoracic aorta (descending aorta)
16 Ascending aorta
17 Left pulmonary vein
18 Pulmonary trunk
19 Left auricle
20 Pulmonic valve
21 Anterior papillary muscle with chordae tendineae
22 Myocardium of left ventricle
23 Posterior papillary muscle
24 Interventricular septum
25 Right and left brachiocephalic veins
26 Chordae tendineae
27 Papillary muscles of right ventricle
28 Left atrium
29 Infundibulum
30 Anterior papillary muscle of left ventricle
31 Left atrioventricular (bicuspid or mitral) valve and chordae tendineae
32 Apex of heart
33 Inferior vena cava
34 Liver
35 Aorta (pars abdominalis)

Anterior aspect of the heart. Dissection of the four valves.

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011



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Chordae tendineae

Image from: Johannes W.Rohen; Chihiro Yokochi; Elke Lütjen-Drecoll. Color atlas of anatomy. 7th edition. Lippincott Williams & Wilkins 2011

Left Atrium

- **Features:**
  - It forms most of the base of the heart.
  - Its wall smooth-walled part
  - The right auricle: contains pectinate muscles (rough-walled).

Left Atrium

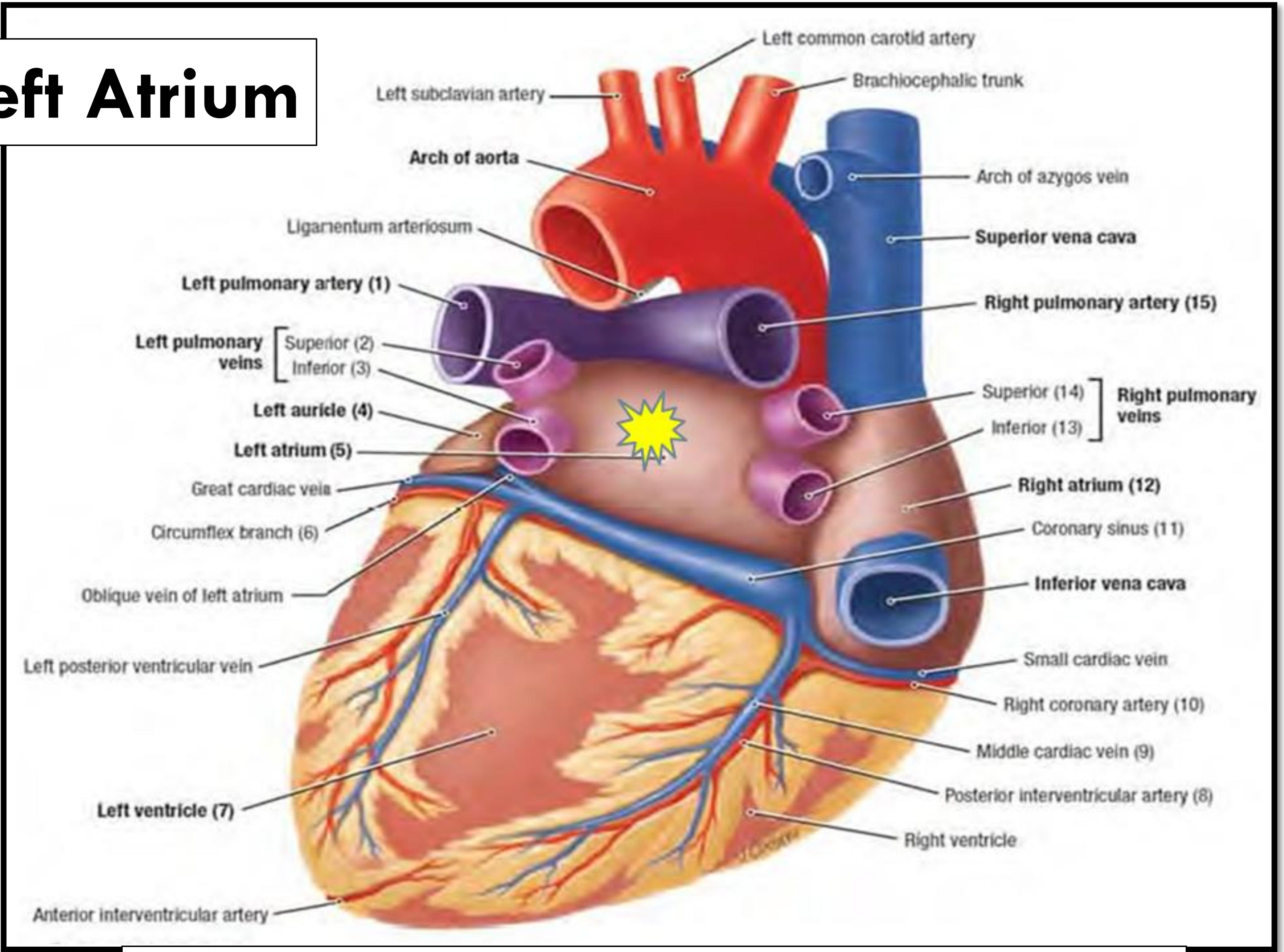
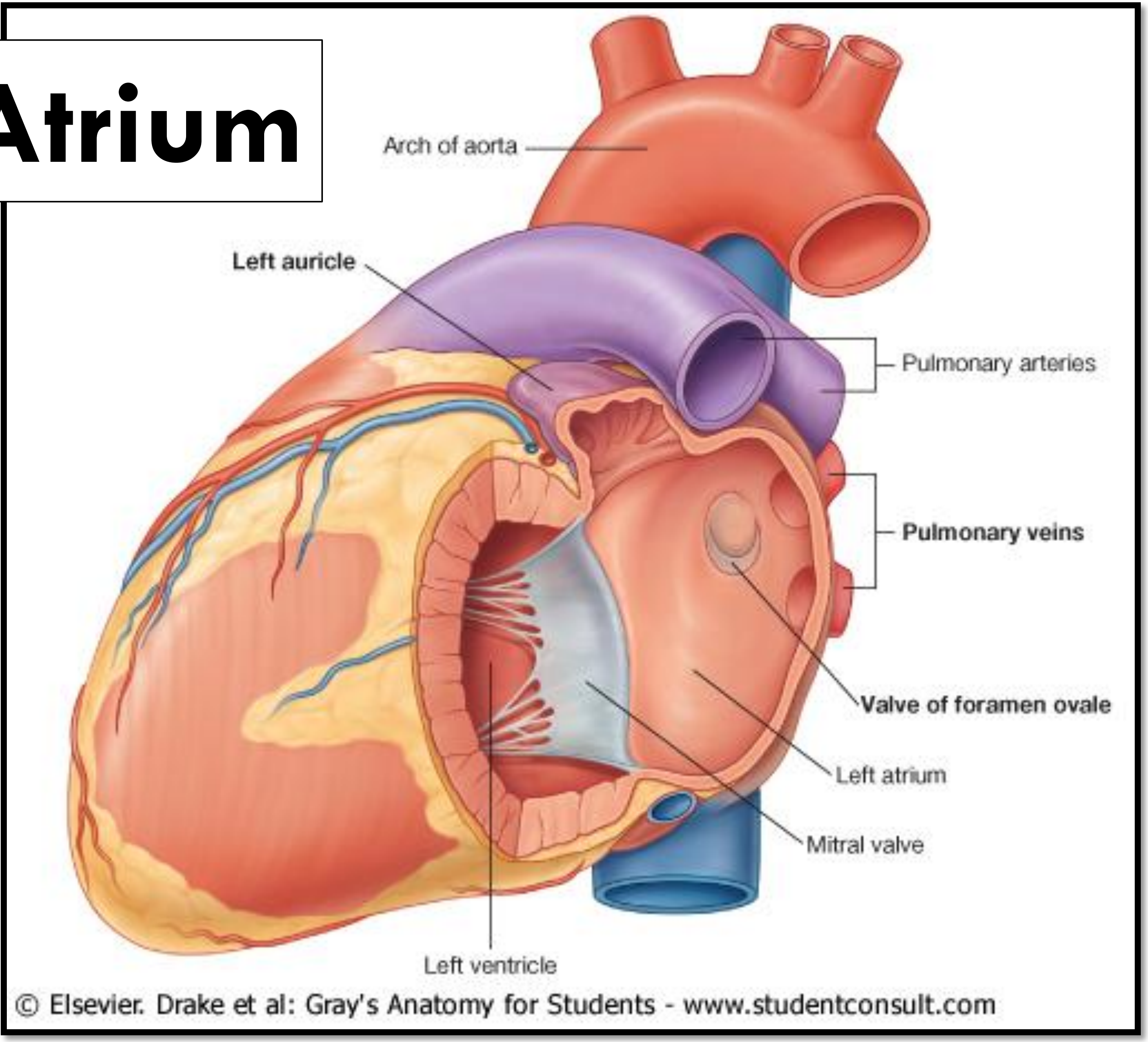


Image from: Agur, Anne M.R.; Dalley, Arthur F. Grant's Atlas of Human Anatomy. 12th Ed. Lippincott Williams & Wilkins; 2009.

Left Atrium (2)

- **Features:**
  - Four pulmonary veins (two superior and two inferior) entering its smooth posterior wall.
  - A left AV orifice (mitral valve) through which the left atrium drains the oxygenated into the left ventricle.

Left Atrium



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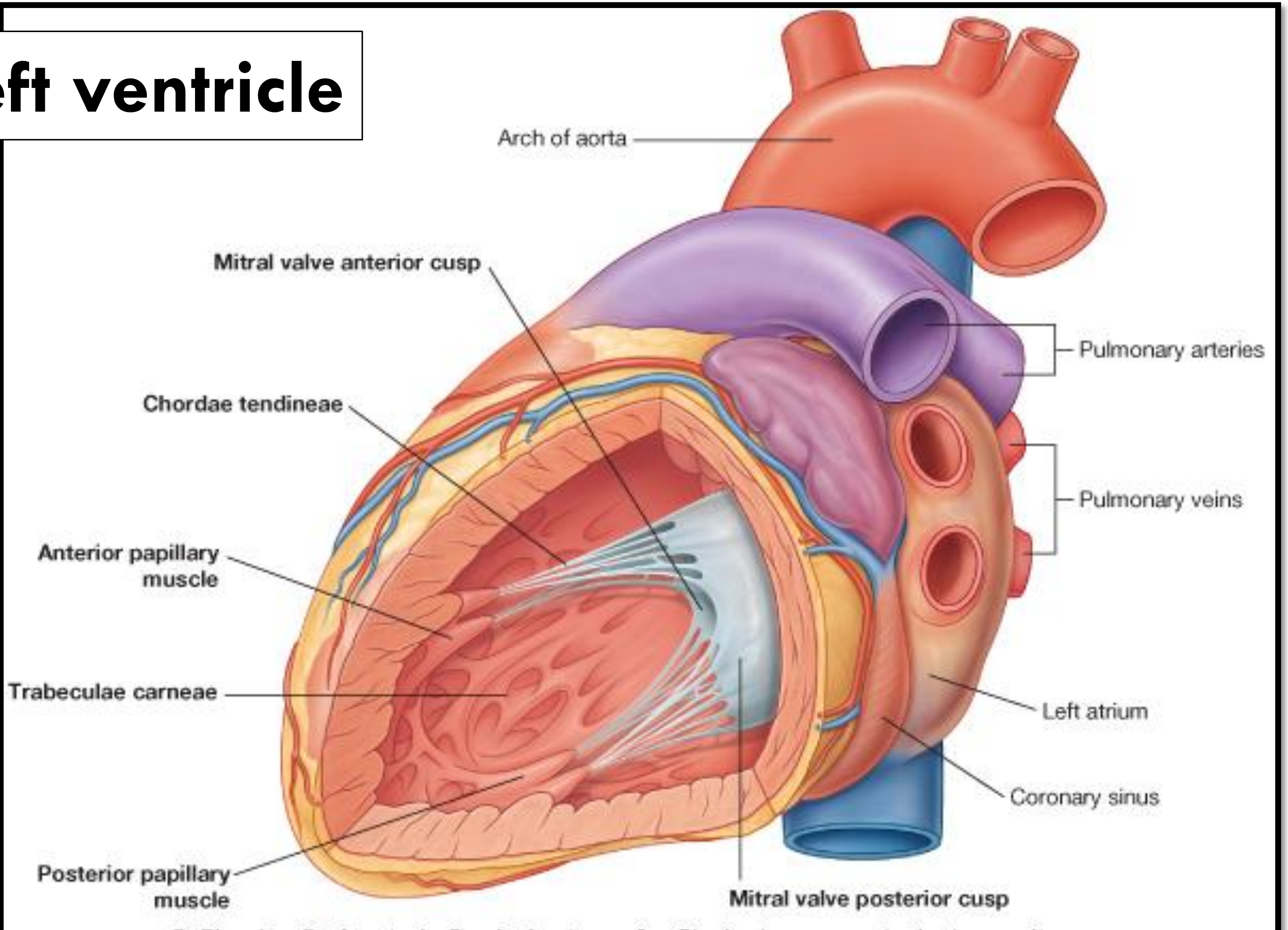
Left ventricle (1)

- It forms:
  - The apex of the heart.
  - Nearly all its left (pulmonary) surface and border.
  - Most of the diaphragmatic surface.

Left ventricle



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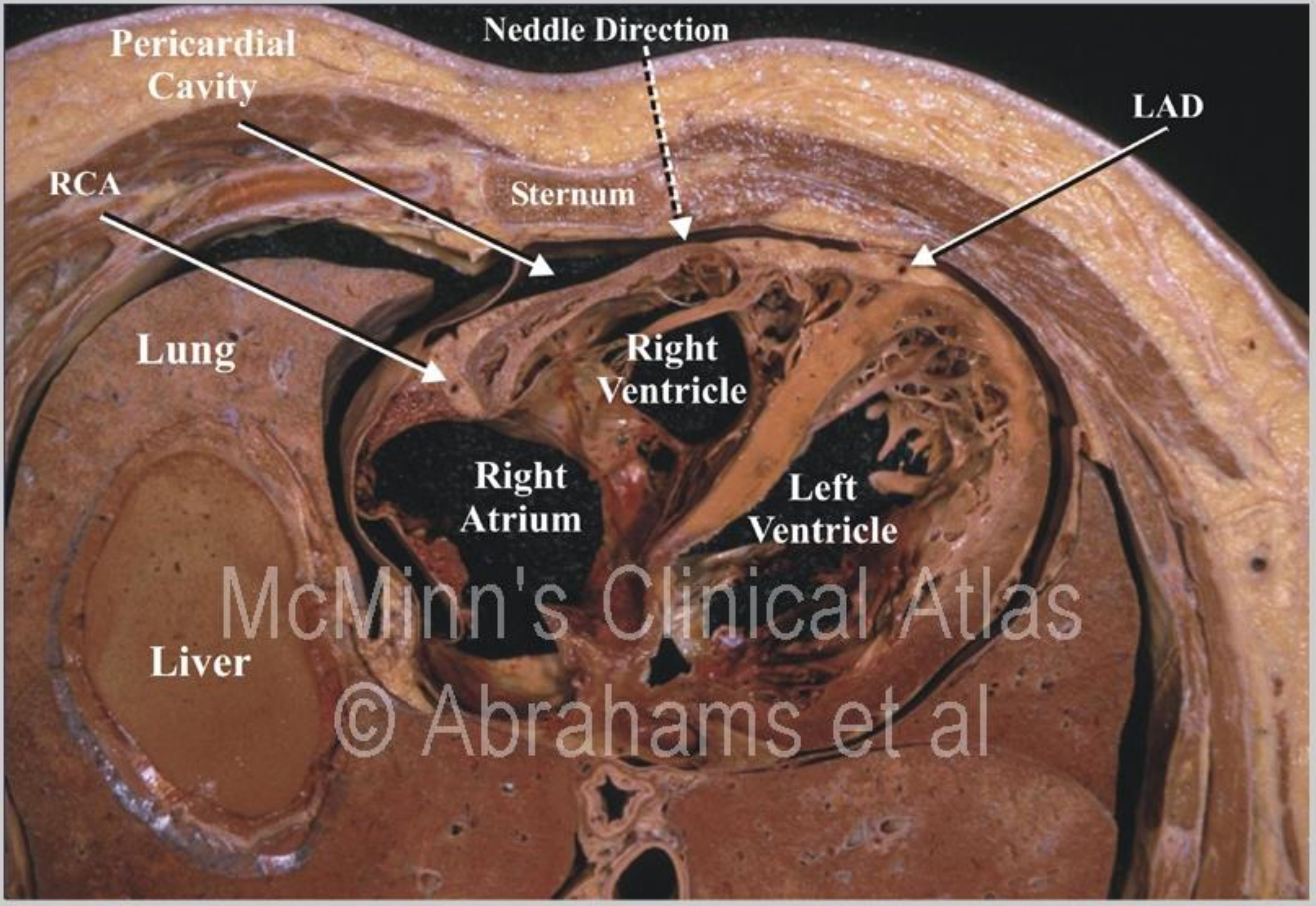
Left ventricle (2)

- **Features:**
  - Walls are two to three times as thick as that of the right ventricle.
  - Papillary muscles that are larger than those in the right ventricle.
  - Trabeculae carneae muscles.
  - Superio-anterior outflow: the aortic vestibule, leading to the aortic valve.
  - A double-leaflet mitral valve that guards the left AV orifice.



McMinn's Clinical Atlas
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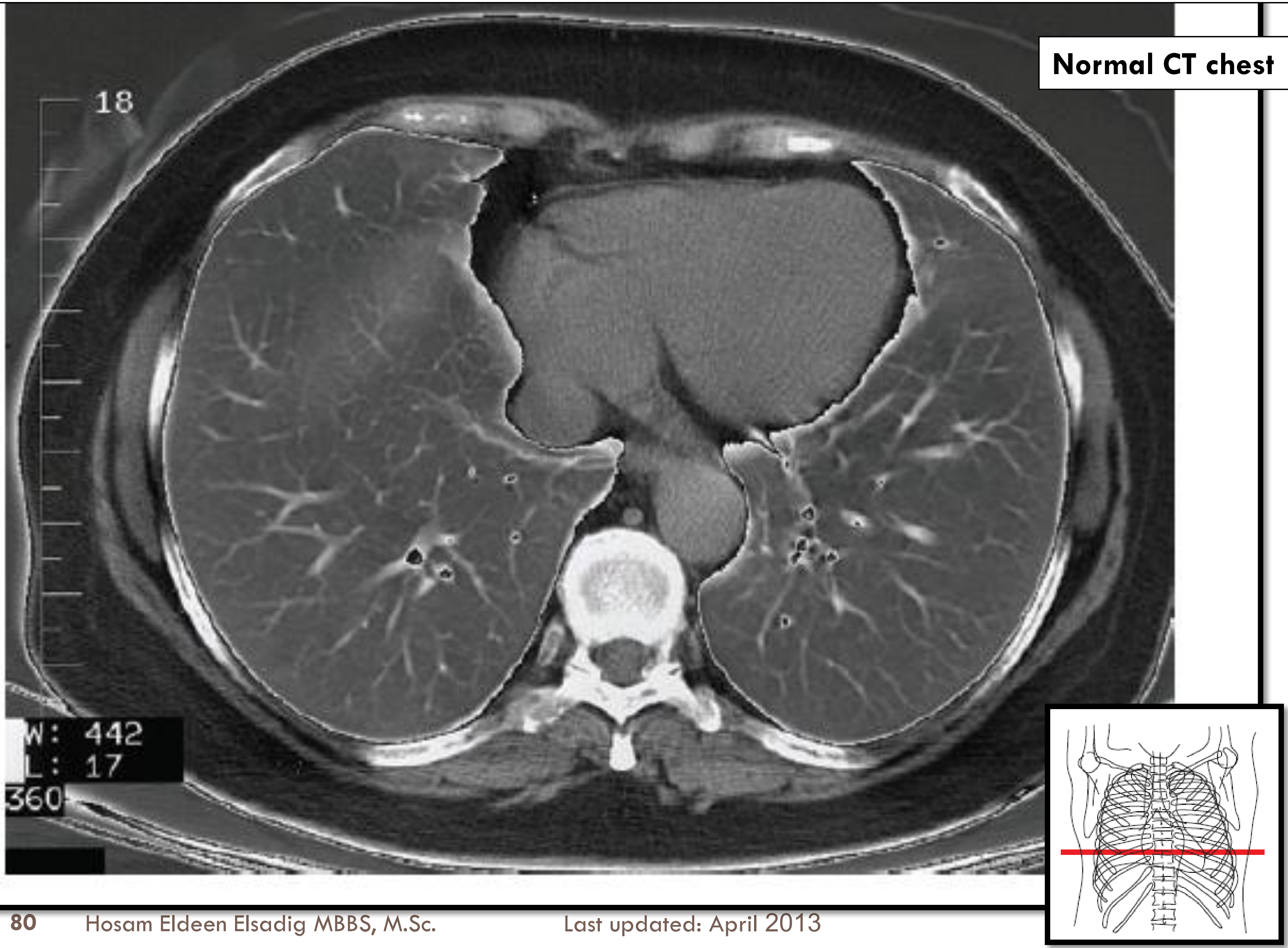
Image from: Abraham's et al , McMinn clinical atlas.

Image from: Torsten B. Moeller; Emil Reif. Pocket Atlas of Sectional Anatomy. 3rd edition. Germany by Appl Aprinta Druck, Wemding; 2005

Normal CT chest



Summary: Lecture's map

- Pericardium.
- Heart:
  - Surfaces and borders.
  - Valves.
  - Champers.

Next lecture: heart (2)

- Blood supply of the heart.
- Innervation and conducting system.

Please try to answer this question

- The apex of the heart is formed by:
  A. Left atrium
  B. Truncus arteriosus.
  C. Right atrium
  D. Left ventricle
  E. Coronary sinus

Please try to answer this question

- The following structure open into the left atrium:
  A. The superior vena cava
  B. The coronary sinus
  C. The anterior cardiac vein
  D. The inferior vena cava
  E. The right pulmonary veins

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